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BIOLOGY OF MARINE MAMMALS: INSIGHTS THROUGH STRANDINGS

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16. Abstract

This report summarizes the proceedings of a marine mammal stranding workshop held August 10-12, 1977 at the University of Georgia, Athens, GA. It provides a summary report of the workshop's activities and recommendations and sections dealing with: 1) The nature and occurrence of marine mammal strandings, 2) Stranding factors, circumstances and theories, 3) Information gained from stranded animals, 4) Recovery and care of strandlings and 5) Proposed regional stranding reporting networks.

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MARINE MAMMAL STRANDING WORKSHOP

Preface

On August 10 through 12, 1977 the Marine Mammal Stranding Workshop was held at the University of Georgia, in Athens, GA. There were 90 people in attendance, 41 of whom were invited participants representing government agencies, and scientific and public display institutions from 19 states (U.S.A.), Canada and England.

The purposes of the Workshop were to:

1. inform federal, state and local authorities having coastal jurisdiction of the nature and occurrence of marine mammal strandings,
2. increase awareness within the scientific community of the kinds of data that can be gathered from well-investigated strandings,
3. establish lines of communication between law enforcement agencies and the scientific community, and thereby minimize potential areas of conflict,
4. establish a plan of action to be instituted at the time of the stranding, with the National Marine Fisheries Service instrumental in coordinating regional efforts,
5. establish the framework of a National Stranding Alert Network with Regional Centers and a central data file, thereby assuring utilization of biological material stemming from each stranding,
6. devise an approach to handling and nursing care of strandings, disseminate information on successful rehabilitation programs now in use, and determine the feasibility of releasing rehabilitated animals,

7. provide a stranding workbook which will include: proceedings from the workshop; a directory of the national and regional centers; offices of appropriate federal, state and local agencies having coastal jurisdiction; a list of scientists and institutions involved with strandings, and those requesting biological specimens; and specific guidelines for the care and handling of live strandlings.

These proceedings reflect the content of the workshop. They are subdivided into distinct working categories: Nature and Occurrence of Strandlings; Stranding Factors, Circumstances and Theories; Data Derived from Strandings; Recovery and Care of Strandlings; Organization of a Stranding Network.

The success of the Workshop and value of these proceedings are due to the effort and encouragement of the participants, and especially to the diligent efforts of the discussion leaders, C. Jones, E. Mitchell, J. Prescott, S. Ridgway, and F. Wood. We are grateful to the Ontario Veterinary College, University of Guelph, for hosting a social hour, and to the New England Aquarium, Boston, for hosting the working luncheon. We owe a special thanks to Ms. Celia Rodd of Guelph, who helped with all stages of the Workshop program, and Mrs. H. Machado, who typed this document. The Workshop was funded by the Marine Mammal Commission, grant # MM7AC020.

J. R. Geraci
D. J. St. Aubin

Guelph, Ont.
Sept. 1978

STRANDING WORKSHOP SUMMARY REPORT

Analysis of Marine Mammal Strandings and Recommendations for a Nationwide Stranding Salvage Program.

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INTRODUCTION

The material which forms the basis of this report is derived principally from the Workshop presentations, working group discussions, and summary reports by each group leader. Additional information was gained from private discussions, some of it bordering on gossip, from intercepting ideas hurled during some peppery debates, and from our own experiences with strandings. (See acknowledgments, page vi and 33).

GENERAL CONSIDERATIONS

Over the past 10 years, there has been increasing awareness of marine mammal strandings among scientists and the general public. Still, the precise reasons for these occurrences remain a matter of considerable speculation.

Solitary marine mammals representing all of the major groups (pinnipeds, odontocetes, mysticetes and sirenians) have been found ashore; mass strandings (3 or more individuals) have been documented in 15 odontocete species and only one

mysticete species. The most frequently documented mass strandings involve pilot whales, *Globicephala* sp., false killer whales, *Pseudorca crassidens*, Atlantic white-sided dolphins, *Lagenorhynchus acutus*, and sperm whales, *Physeter catodon*. Only a few strandings have ever been thoroughly documented owing in part to sporadic observations along remote or inaccessible coastline, inaccurate or inappropriate reporting and/or recordings, as well as an element of disinterest. Such documentation requires considerable time, money and effort, and the availability of qualified people.

Recent efforts to piece together data gathered during an intensive three year effort along the East Coast, have revealed the following:

- there appears to be a peak stranding period during the spring months. The reasons for cetacean strandings are still not clear; abandonment or separation as infants accounts for most pinnipeds.
- inshore odontocete species are frequently cast ashore dead while offshore odontocetes often live-strand.
- previously unknown age and sex biases in herd composition are now recognized for some species.
- there appears to be site-predilection for some strandings; there are areas where certain species appear to strand repeatedly.
- single and mass live-stranded animals, when returned to sea, very often restrand.

- data are heavily biased by observational effort, being very high in a few selected areas and totally lacking elsewhere.

STRANDING FACTORS, CIRCUMSTANCES, AND THEORIES

All marine mammals found along a shoreline are referred to as "stranded," although a distinction must be made between those which come ashore alive, and those which are simply washed ashore dead. The amphibious pinnipeds and sea otters are considered to be stranded when unable to leave the shore because of accident, parasitism or disease. Weak and malnourished seal pups and young sea otters often strand following abandonment or separation from the female parent. Though there is increasing speculation that disease is involved in a significant number of single stranded cetaceans, absolute correlations have only been documented in a few cases. Many solitary stranded animals are found with no discernable evidence of disease. The role of disease in strandings must be interpreted in light of findings in non-stranded (incidentally killed) animals.

The causes of mass strandings are not all clear. Factors which have been implicated include meteorological and hydrological conditions, man induced disturbances, inshore feeding by pelagic species in dangerously shallow waters, echo disruption, alarm response with reversion to primitive ancestral behavior, and disease. No single factor can account for the diverse circumstances surrounding most of the strandings, yet

each must be considered, alone or in combination, as a basis for further analysis. The factors can be catergorized as follows:

1. <u>Physical Factors</u>

a) <u>Meteorological/Hydrological</u>: Some observers suggest that there is an increased number of single odontocete strandings associated with adverse weather conditions. As yet, there are no substantiating data. Stranded pinnipeds are more likely to be found following a storm, especially pre-weaned pups (sea otters, elephant seals and east coast harbor seals). Some cetacean strandings appear to be accidental entrapments caused by rapidly falling tide.

b) <u>Topographical</u>: Most strandings occur on gently shelving beaches although records are biased by observational effort. Sites of recurring strandings over the years might suggest that offshore bottom features, such as submarine canyons that extend toward shore, may be a factor in these stranding sites. When considering the topography of the shoreline as a factor in strandings, one must bear in mind the impossibility of stranding along a precipitous coast. Certain complex coastal topographies appear to provide natural traps, in which cetaceans are among the many diverse species which become trapped (e.g. sharks, other fishes and squid at Wellfleet, Cape Cod, MA.)

2. Biological/Behavioral Factors

a) Population density: It has been suggested, but as yet without convincing evidence, that population size and density may be a factor in strandings, perhaps through density-dependant pressure leading to dispersal into hazardous feeding areas.

b) Disease: There is evidence that parasites and other disease conditions are often associated with solitary strandings. The available evidence with regard to mass or multiple strandings is inadequate to draw any conclusions.

c) Social Cohesion: This is clearly a factor in the observed behavior of odontocetes in some mass strandings. It is less apparent in those strandings in which animals have come ashore over a wide (> 20 km) stretch of beach, or in strandings which have taken place over prolonged periods (up to one month) involving even greater expanses of beach.

d) Inshore feeding: Inshore feeding behavior in dangerously shallow or receding waters provides a simple and attractive explanation for cetacean strandings, but there is no supporting evidence in most cases. Circumstantial evidence of abundant "prey" species at the time/site of stranding is not supported by stomach contents analysis of stranded dead specimens. This can be attributed to:

1. negative feeding/stranding correlation
2. vomiting of stomach contents during stranding
3. digestion of contents during stranding

e) Decreased responsiveness: Odontocetes in some mass strandings have appeared "semi-conscious," and have responded only to excessively rough handling (pummeling, rolling, being moved about) before "recovering" sufficiently to swim away.

f) Acoustic interference: The hypothesis that the cetacean sonar system is ineffective or misleading in the shallows

of gently sloping shores, resulting in animals blundering ashore, is weakened by the following considerations:

1. sophisticated sonar capability has not been established as a universal component in all cetaceans.
2. stranded animals which are returned to sea usually restrand.
3. echo characteristics of "typical" stranding sites have yet to be mapped.

g) Harassment: The influence of predator avoidance and alarm has been suggested as at least one component in a number of strandings. Though documentation is lacking, such an influence is likely in view of the known harassment/driving techniques which formed the basis of many shore-based whale fisheries. Man-induced injury has been established as a reason for individual strandings within most of the major groups, and especially the manatee.

h) Parallel with other animal groups: Stranding is apparently a maladaptive behavior in cetaceans. There are no obvious parallel "suicidal" behaviors in other animal groups, aquatic or terrestrial.

i) Reversion to primitive behavior: None of the stranding factors accounts for the apparent "intent" to beach or strand. This, together with apparent "refusal to accept freedom" when returned to sea, has led to a comprehensive hypothesis (see paper by F. G. Wood in this volume) that the requirement to seek safety on land early in cetacean evolutionary history has persisted to the present time. This "primitive" behavior is seemingly paralleled in the land seeking stress-response of the marine iguana, Amblyrhynchus, of the Galapagos Islands, but in the latter case, this behavior has obvious survival value.

Recommendations for relevant studies

Studies should be carried out to further elucidate the nature and causes of strandings. Such studies are largely a matter of retrospective analyses of documented events which can be carried out at a minimum cost. Other studies can be prioritized as follows:

a) Retrospective analysis of all documented strandings categorized as single/mass, live/dead, inshore/offshore species noting season, location, topography, hydrology, meterology, biological factors (i.e. feeding, predator-prey interaction, harassment, group cohesiveness, parasites/disease). Relevant categories should be compartmentalized into pre-stranding, stranding, and post-stranding events.

Special attention should be paid to species pairs which mass strand vs those which do not, i.e. *L. acutus* vs *L. obliquidens*, and *Stenella longirostris* vs *S. attenuata*. This latter pair may well reveal some behavioral differences useful in the context of the tuna-porpoise problem.

b) Survey of past and present dolphin/whale driving techniques, noting the behavior of animals in such drives (e.g. dispersal/cohesion, vomiting, harassment time/intensity, effectiveness of various shore configurations). It is important to note that *Globicephala*, which formed the basis for most successful whale drive fisheries, is also a mass strander.

c) Maximize data collection relevant to the above categories at all future strandings (see Level A, B, and C data, pp.25-31). The effort requires minimum funding.

d) Mark by tagging stranded animals before returning them to sea. Cattle ear tags are inexpensive and easy to apply. Freeze branding is a more permanent technique,

but requires some advance preparation to have the necessary materials on hand. Radio tags would facilitate tracking, but require considerable financial and logistic support.

e) Encourage detailed observations/records of behavior preceeding and during stranding.

f) Observe behavior of marked animals held offshore in a seine-net or other floating enclosure. It should be determined whether animals sequestered in this manner have greater chance of survival after release in the open sea.

g) A controlled study should be carried out on live-stranded animals aimed towards establishing differences in longevity between those brought into captivity and those marked and returned to sea. Captive studies should also be directed towards the accoustic behavior of these animals, as compared with animals under more normal circumstances of captivity.

h) Studies of cetacean behavior in the natural environmen, such as by aerial or shipboard survey, should continue to be opportunistic rather than directed specifically toward strandings, as there appears to be no evidence at present that such costly research would be fruitful.

KINDS AND VALUE OF DATA DERIVED FROM STRANDINGS

GENERAL

Strandings provide a valuable source of data on animals which are biologically or legislatively unobtainable; this is especially true in the case of species presently listed as endangered, i.e. the great whales, the manatee.
Data derived from such studies help to fill

important gaps in present knowledge regarding stocks, life history, etc. One example of the need for such population oriented information is the dolphin management situation in the U. S. west coast. Applications for permission to take bottlenosed dolphins have not been approved by NMFS in the past because of the lack of basic data on population status and impact of the proposed take. Data from stranded animals will help to meet this need. As a case in point, along the eastern seaboard, more than 80 Pseudorca and 200 Tursiops have been studied through documented strandings since the institution of SEAN.

This information can also help to direct research and provide data necessary to the functioning of the International Whaling Commission subcommittee on small cetaceans. Such information is sorely lacking at the present time. The kinds and value of data which can be derived from strandings can be categorized as follows:

A. Management

1. Stock definition: through an analysis of stranding time/place/frequency, it is possible to gather information on range, distribution, and fluctuations in stock composition and density. Through parasite tags, sub-populations can be categorized according to feeding habits and location. Through detailed taxonomic/morphometric studies, information can be gained on recruitment patterns from distinct stocks.

2. Life History: life history data which have been obtained from strandings are: reproduction time/rate, duration of gestation and lactation, growth and development, age and size at sexual maturity, feeding habits, herd composition/segregation, mortality rates and causes, and the operation of selective forces within the population. However, it is recognized that because of sample

bias, these data are difficult to obtain from all species. The feeding habits of some cetaceans are known only through strandings. Through two mass strandings of the Atlantic white-sided dolphin, *Lageno-rhynchus acutus*, the animal has been brought from virtual obscurity to one of the better understood species with regard to life history. Life history data such as length at maturity are a requisite to granting permits for the capture (for display) of animals not traditionally held in captivity. Such data are easily derived from stranded animals.

3. Environmental Impact

a) Man-animal interaction: Strandings have provided keen insights into the changing course of man-animal interaction. The study of stomach contents/food habits helps to establish levels of competition between animals and fishermen for valuable food stocks (e.g. the relationship between seals and commercial salmon stocks along the north-west coast).

Intentional harassment or accidental interference can be determined through post-mortem examination of stranded specimens. Through such investigations, it is now known that at least 50% of Florida manatee deaths are man-related (fish hooks, dams, boat propellers); juvenile minke whales are frequently entangled in Cape Cod fishing weirs. Increased effort into such studies will undoubtedly increase our awareness of the kind and extent of man-animal interactions.

b) Indicator species: Since many marine mammals feed at the top of the food-web, they act as useful indicators of oceanic pollutants against which future impacts can be assessed. Differences in pesticide and heavy-metal residue concentrations in tissues might be used to assess stock discreteness within a given species. Samples from

stranded animals can provide information on residue accumulation with age, some measure of clearance rates, and toxic effects.

B. Educational, Exhibit, and Scientific Benefits

1. Education: Stranded animals are a relatively unexploited source of specimens and biological material for teaching purposes.

2. Exhibit: Rehabilitated strandlings can be made to fill an important need for otherwise unobtainable public display specimens. Such animals can be used to fulfill permit applications in lieu of taking wild specimens (see Care and Disposition of Live Strandlings).

3. Scientific: Stranded animals have been a valuable source of research material for anatomy, physiology, biochemistry, genetics, toxicology, and medicine. By increasing awareness among scientists of the opportunities presented by such specimens, the number of requests for material from wild-caught animals will undoubtedly decrease. The availability of such material will also stimulate more interest in marine mammal research among those now unaware of this opportunity.

Rehabilitated live strandlings can also provide a source of specimens for research oriented toward a better understanding of their needs in captivity, i.e. nutrition/ food preference/requirements, growth and development, reproduction, efficacy of therapeutic agents, as well as general biology and medicine.

C. Parasites, Diseases, Public Health

Parasites are a prominent feature in many cetacean strandings. In some cases, they are associated with significant organ damage, so much so that it is tempting to relate their presence to the actual stranding event. Yet only in a few cases can parasites be held accountable for the death of an animal.

There has been a great deal of popular and scientific news coverage of the middle ear nematodes of the genus *Stenurus*, and their relationship to echo-disruption/stranding. To date, there is no solid evidence that *Stenurus* functionally damage the middle or inner ears, at least by their physical presence. Our information regarding the role of parasites in mysticete strandings is extremely limited.

Apart from the undecided role of parasites in strandings, they may prove to be of value as biological indicators. The use of parasites in differentiating fish populations is well known. In mammals, they may aid in determining migration and feeding habits, and also supplement data on intraspecific variation.

There has been some renewed concern over the public health significance of certain diseases found within marine mammal populations. These include San Miguel sea lion virus, leptospirosis, seal finger, and Lobomycoses, a fungus disease. At the moment, there are no indications that any public health problem exists but the potential for overreaction on the part of public and some scientific communities demands that we continue to closely monitor diseases which are potentially communicable to man and other (domestic) animals. At present the only real concern is the removal of potentially hazardous decomposing material from public beaches.

Studies on disease prevalence will help clarify causes of mortality. For example, parasitic mastitis in some free-ranging odontocetes is considered to interfere with reproductive success. Investigations on diseases will also provide an increasing bank of medical data which will help to maintain these and related species in captivity.

Recommendations on Maximizing Data

1. Provide a standard form which will be used in all stranding investigations, and which will establish levels of priority

in the collection of data. These levels are defined as follows:

<u>Level A</u> (See p. 25)

Minimum data required to catalogue the event. Disposition of samples collected for subsequent laboratory analysis, e.g. stomach contents, reproductive organs, fetuses, teeth for aging.

<u>Level B</u> (See p. 27)

Identify materials and protocol for collection of specimens for specialized studies on parasitology, pathology, and toxicology.

<u>Level C</u> (See p. 28)

Specialized analyses required to augment basic data.

2. Encourage or stipulate as part of government grant and contract policy, the publication (or otherwise making available) of all data relevant to the above categories. Maximize use of presently existing data by determining location of sources of data, and inventory such sources for relevant information. This may best be accomplished by a committee charged with providing a list of all individuals and laboratories willing to collaborate on studies of:

   1. <u>Life History</u>
      <u>Committee</u>:

      Brownell, R.
      Mitchell, E.
      Perrin, W.

2. Pathology/Toxicology/Parasitology

Committee:

Cowan, D.
Dailey, M.
Geraci, J.
Kenyon, A.
Medway, W.

CARE AND DISPOSITION OF LIVE STRANDLINGS

GENERAL

The first consideration at any stranding event should be the care and well-being of live animals. Some on-site problems might seem easily solved simply by returning the animals to sea. Most often with pinnipeds and almost invariably with cetaceans, such procedures are ineffective and hazardous to the animal. Consideration instead should turn to rehabilitating such strandlings. Rehabilitation programs are costly and can overburden facilities.

Eventually, rehabilitated animals must be disposed of, either by transfer to another institution, which may not be possible under existing law, or by returning them to the sea, which may be precarious in view of the animals' human dependency. Returned animals will never contribute substantially to the population, and are therefore not important in terms of conservation.

The problems and some proposed solutions to the care and disposition of live-stranded animals can be categorized as follows:

1. Return to sea:

Returning single stranded cetaceans to sea is generally regarded to be futile. The animals are often diseased, and they usually restrand, immediately or at a later time, sometimes on an inaccessible shore. Pinnipeds, being amphibious in nature, are generally in poor health

when unable to leave the beach. Consideration should be given to rehabilitation rather than returning such animals to sea. If conditions do not allow for removal to holding facilities, the strandlings should be left in place rather than be prodded back to sea.

Success at returning mass stranded cetaceans to sea has also been poor, yet it is virtually impossible to rehabilitate such large numbers of animals. Under these circumstances, animals which are returned to sea should be marked (see Strandings Factors, Circumstances and Theories, Recommendation d. and f.).

2. Euthanasia: animals which should not be returned to sea (see above section 1) and which cannot be removed to a suitable holding facility should be euthanized and processed for disposition. Other criteria for euthanasia should be based on duration of beaching, type of exposure (sun/cold), general condition (lacerations) and size of the animal. The decision to euthanize must be made by a knowledgeable individual. Not to do so either through public pressure or fear of legal repercussions is cruel to the animal, a potential threat to public health, and the focus for public nuisance. Present laws prohibit euthanasia without proper authorization, even by a veterinarian. It is suggested that through letter of agreement or transfer of authority from an enforcement agent, the mechanism for obtaining permission to euthanize be facilitated and that a number of responsible and qualified individuals be designated within each Regional Stranding Network (see Regional Network Organization).

3. Recover and Rehabilitate: suitable animals must be removed to adequate holding facilities as soon as possible after the stranding. In this regard, a list of holding facilities, along with the capacity and personnel capabilities of each, should be compiled within each Regional Stranding Network.

These facilities should be given authorization, under existing law, to hold such animals.

Rehabilitation programs are necessary for the well-being of stranded animals. Though nursing and medical care may be costly, it is often in the best interest of the institution to maintain this program. Suggestions for partial cost recovery are detailed below (Section 5).

4. Retain or release: at the present time this problem mainly concerns pinnipeds and sea otters as only a small number of cetaceans have been successfully rehabilitated. Rehabilitation programs are variably successful in either restoring the animal to apparent "complete" health or to some marginal level of existence. The quandary of whether to retain or release strandlings concerns only those animals which are in good health. The decision to release healthy strandlings is mandated by the Marine Mammal Protection Act, and yet it is fraught with problems which can be summarized as follows:

   a) The rehabilitated animal can become human-dependent in terms of food and total environment. There have been problems with released animals provoking fear by approaching unsuspecting persons, jumping onto pleasure craft, etc.

   b) The animal may not be capable of interacting normally with other members of the species.

   c) The animal may have lost its natural capacity to avoid predators.

   d) There are indications that mortality in feral male elephant seals, *M. angustirostris*, may reach 98% by 8 years of age. As a result, returning these animals may not be in their best interests.

Institutions must be given authority under the law to retain endangered or other marine mammal species which are not suitable for release.

Despite these problems, which take a conservative approach to the question of release, there appears to be little choice but to engage in large scale release programs in those areas where strandlings are obviously overburdening existing facilities and where no other alternatives for disposition are available. In order to focus in on the real problems inherent in releasing animals, attempts should be made to maximize relevant information. This can be done effectively and inexpensively by permanently marking released animals, and increasing public awareness of the presence of such animals so as to assure greater information yield from observers. We recommend that the details of such a program be considered by a committee composed of:

J. Antrim
S. Katona
B. LeBoeuf
J. Prescott
L. Smalley
H. Winn

5. Disposition of rehabilitated animals:

Occasional strandlings do not present a serious burden to most institutions. The problem of overcrowding arises in those institutions which have become a focus of attention for strandings or which are located in an area where strandings occur frequently. In order to facilitate the transfer of rehabilitated animals from the parent facility to other exhibit/research institutions the following recommendations are proposed:

a) Establish and maintain an updated directory of available rehabilitated animals. This function can be assumed by the National Office (see below), which could operate in conjunction with the American Association of Zoological Parks and Aquaria (AAZPA) inventory of animals.

b) Simplify the mechanism of permit application for the transfer of such animals in order to encourage the preferential utilization of these specimens.

c) Within existing laws, re-evaluate the interpretation of "longevity" with respect to rehabilitated animals; it is likely that such animals would have a poor survivorship.

d) Allow rehabilitating institutions to recover a portion of their costs. It can, and perhaps should, be considerably less than the market value of wild caught specimens.

e) It is apparent that some rehabilitated animals are not acceptable for certain types of exhibit and/or scientific research. Nevertheless, animals should be drawn preferentially from these pools to supply permit needs, unless there are strong indications otherwise.

f) A committee should be formed to establish criteria for the disposition (release/hold/transfer) of rehabilitated animals:

J. Antrim
L. Garibaldi
T. Otten
S. Ridgway

AGENCIES REQUIRING INFORMATION DERIVED FROM STRANDINGS

All agencies which influence or administer the laws relevant to marine mammals must have the best available information with which to act. These are the agencies which should be supporting the research, and which should be integrated in any large scale program thereby ensuring the collection of data. These include:

Bureau of Land Management/Outer Continental Shelf
Fish and Wildlife Service
Marine Mammal Commission
National Marine Fisheries Service
Office of Coastal Zone Management
Sea Grant

Such information is necessary to the decision making processes involved with:

- enforcement policy with regard to marine mammals
- influencing policy with regard to revisions in the law
- identifying & directing areas of research relative to life history, stock assessment/distribution/mortality, environmental impact, man-animal interaction
- permit applications for the taking of marine mammals
- disposition of marine mammals on the beach

REGIONAL STRANDING NETWORKS

GENERAL

So as to maximize data from strandings, provide an efficient format for the dissemination of such data, ease the efforts of law enforcement agencies, encourage close cooperation between enforcement agencies, investigators and institutions, and eliminate conflicts and duplication of effort among those investigating strandings, a scheme of regionally organized stranding networks is proposed.

Such regional networks should be organized along the lines of existing regional designations under the National Marine Fisheries Service, i.e., Northeast, Southeast, Southwest, Northwest, and Alaska. It is proposed that Hawaii and the Pacific basin constitute a separate region for obvious geographic reasons. For the same reason, Puerto Rico and the U. S. Virgin Islands, though under jurisdiction of the Southeast network, may require some degree of autonomy in order to function effectively as part of a greater Caribbean network.

Each regional network will consist of representatives from the National Marine Fisheries Service, Fish and Wildlife Service or other law enforcement agencies, state and local fisheries officers with expressed interests, scientists, and representatives of institutions for live exhibit (see page 300) The responsibilities of each network are as follows:

a) select an individual or office to coordinate activities within the region. Method of selection as well as terms of appointment will be left to the regional participants.

b) assure an effective mechanism for response to every stranding (stranding response teams).

c) assure that first considerations be given to health and welfare of live strandlings and then to gainful disposition of carcasses.

d) ensure thorough and uniform collection of Basic Minimum Data (Level A) and report all such data to the National Office (see below).

e) distribute within the region an updated list of all interested and authorized institutions capable of caring for live animals (see Care and Disposition of Live Strandlings, Section 3).

f) identify those individuals/institutions within the region carrying out programs beyond Basic Minimum Data collection,

and specify their research needs.

g) refer requests for material to appropriate individuals within the region.

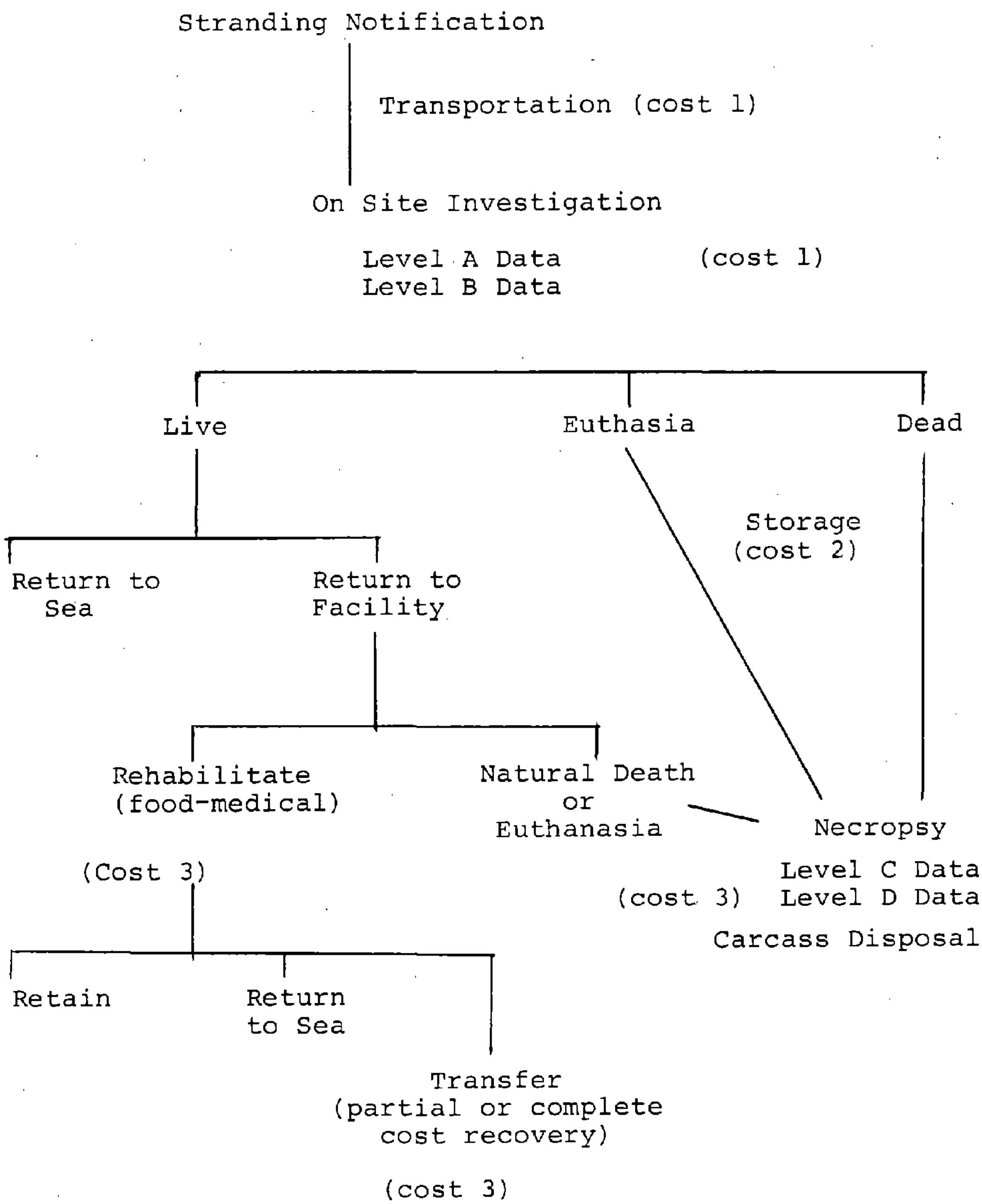
h) establish a formula for the dispersal of funds to help defray costs of live animal collection and care, disposition of dead animals, and the collection of Basic Minimum Data.

FUNDING

It is recognized that the contribution of individuals and institutions involved in the network will be largely one of interest rather than financial encouragement; nevertheless the availability of funds will ultimately determine the quality and effectiveness of the program. Though it is unlikely that funds can or should be made available to support all aspects of a national stranding program, funding must be appropriated for Basic Minimum Data collection. The specialized analyses (Level D) are considered to be an essential part of the network, but should only be carried on the basis of available funding.

We propose a formula funding scheme for single and smaller mass strandings for which funds will be made available on the basis of levels of effort directed towards the health and welfare of live animals and the gathering of data and samples, up to a pre-determined maximum for each animal/event. Investigations of mass strandings often require a team effort over a prolonged period, and as a result, involve special funding consideration. Specific formula funding for mass strandings should be detailed within each region in the initial stages of organization.

PROPOSED FORMULA FUNDING SCHEME



In the proposed scheme, each cost-area is identified as a section of the scheme for which efforts can be compartmentalized, and funded accordingly (Fig. 1). In this way, the mechanism is provided for fair and equitable funding of each response team within the region and each region within the national plan. It is implicit that each cost-area be funded to a pre-established maximum. Otherwise, injudicious use of such items as helicopters for transport, aerial survey to examine stranding sites, and exhorbitant medical fees for individual animals or events may well absorb the entire annual budget for the region. The details of this scheme, as well as maximum allocations for each cost-area should be detailed by committes as follows:

<u>Cost area 1</u>

Asper
Garibaldi
Mate
Mead
Nitta
Perrin
Shallenberger

<u>Cost area 2</u>

Beverly-Burton
Cowan
Dailey
Dietrich
Geraci
Kenyon
Woodard

Cost area 3

Antrim

Dunn

Gornall

King

Otten

Prescott

NATIONAL OFFICE

GENERAL

The need exists for a small office to provide a mechanism for data input and retrieval, and to maintain an open channel of communication among the regional networks. The office must be inexpensive, cost-effective, and free from the influences of a single individual or organization. It should be able to collate and disseminate basic information quickly and effectively.

The concept of attempting to communicate more detailed research data on national and international levels does not appear to be workable at the present time. This should be the subject of a future workshop following an analysis of user needs for such a plan, and the availability of funds and authority to implement the plan. At the present time, the handling of detailed stranding data (beyond level A) remains with the regional network.

This plan proposes to designate a small OFFICE, made up of two or three people including clerical support, located in Washington, D. C., and organized along the lines of the "Stranding Event Alert Network" (SEAN) of the Smithsonian Institution, possibly augmenting this office. Ultimate authority for the functioning of the OFFICE should be with one or more of the federal agencies responsible for marine mammal activities. The OFFICE will maintain a list of all individuals, institutions, and agencies active in the

stranding-salvage program, noting the particular interest of each. This list will be kept up to date by continued input for the regional centers. The OFFICE will maintain an inventory of basic data derived from strandings (provided by regional networks), including that of all past events. The OFFICE will report, on a monthly basis, all stranding events to all participants and agencies in the above list. It will also provide periodic collated summaries (bi-annually) of all stranding events. The National OFFICE will refer requests for specimens, material and data, to regional coordinators. The OFFICE will be actively involved in a communication capacity only in unusual circumstances such as a large mass stranding or multiple live strandings which require special attention. All other communication needs within and between regions, including information on care, salvage, transportation, and other techniques which will be of overall benefit to the national plan, must be handled by the regional networks. There is no question of propriety of information regarding the ultimate publication of such data, since the Office will only handle those few data which are mandated under existing laws.

Level A Data: Basic minimum data from all stranding events (to be submitted to the National Office)

1. Investigator - name
   - address (institution)

2. Reporting source

3. Species - preliminary identification (by qualified personnel)
   - voucher (supporting material)

   a) photograph - full lateral view (cetaceans); dorsal view (pinnipeds); dorsal, lateral, ventral views of whole carcass, with close-up of head (when possible). Include a card with field number in each photo.

b) specimens - canine tooth or entire mandible (pinnipeds); 2 pieces of midrow baleen, or bulla if baleen missing (mysticetes), tooth counts and samples, or entire skull for difficult species (odontocetes).

4. Field number

5. Number of Animals - total

   - sub groups (fragmented mass stranding)

6. Location - preliminary description (local designation)

   - latitude and longitude (to 0.1 minute, if possible) with closest named cartographical feature (USGS 1: 250,000 series) as determined subsequently in the lab.

7. Date, time - first discovery

   - of data and specimen recovery

8. Length (Girth and Weight, when possible)

   a) cetaceans and sirenians - tip of rostrum to fluke notch

   b) pinnipeds - tip of rostrum to tip of tail, lying on back.

9. Condition - recorded for both discovery and recovery times. Categories as follows:

   1 - alive

   2 - freshly dead (i.e. edible)

   3 - decomposed, but organs basically intact

   4 - advanced decomposition (i.e. organs not recognizable, carcass intact)

   5 - mummified or skeletal remains only

10. Sex

   a) cetaceans - probe genital slit (anteriorly directed are female, posteriorly directed are male)

   b) pinnipeds - position of apertures

   c) sirenians

Level B Data: Supplementary onsite information. Augments data on life history and the stranding event.

1. Weather and tide conditions

2. Orientation of carcasses

3. Offshore human/predator activity

4. Presence of prey species

5. Behavior - pre stranding
   - stranding (on beach)
   - after return to sea

6. Samples collected for subsequent analysis

   A. Age Determination

      a) odontocetes - 4-5 adjacent teeth from the middle of the tooth now.

      b) mysticetes - minimum of one ear/plug, preferably in situ in a sample of external auditory meatus, or in a glove finger.

      c) pinnipeds - minimum of 1 canine tooth - claw

      d) sirenians - tusk, where present

   B. Reproductive Tracts

      a) females - both ovaries, uterus, fetus (if any) and measurements and samples of mammary glands.

      b) males - one testicle with epidydimis, or samples with weights and measurements, baculum (when present), vas deferens.

   C. Stomach Contents

      - weigh contents, if possible
      - preserve in alcohol (never in formalin)
      - freeze whole, if possible

7. Disposition of carcass

Level C Data: Necropsy Examination and Parasite Collection

1. Necropsy

Precise recording of findings and appropriate preservation of tissue are of great importance to an understanding of disease conditions. The most important characteristics of an abnormality are its SIZE and LOCATION. Also important are features such as COLOR, TEXTURE, and SHAPE, as well as the nature of the transition from normal to abnormal tissue, that is whether the boundaries are sharp or vague. All findings are described in STANDARD ENGLISH using NON-TECHNICAL TERMS. Lesions are described using terms such as raised, flat, depressed, rough, smooth, velvety, warty, yellowish, round, irregular, etc. Photographs should be made whenever possible, and should include a ruler or some other non-ambiguous reference object.

External Examination - Describe all unusual features such as marks, abrasions, parasites; examine mouth and teeth etc.

Internal Examination - Samples are to be taken routinely from all organs including brain, muscle, endocrine glands and viscera. When an organ is normal, a random section should be preserved in formalin. Any abnormality should be sampled with an adjacent piece of normal tissue. If an organ is studded with many discrete lesions, all apparently identical, sample only two or three. Describe organs as normal appearing, if that is the case. Vessels and ducts are normally opened throughout their length. While this is in theory desirable for the intestine, sampling of two or three

tubular sections may be adequate. All major organs are weighed after cleaning of excess fat and extraneous tissue. Large organs are weighed in pieces, and the partial weights added. Hearts are normally weighed with a short cuff of aorta.

Preservation of tissue

Formalin (10% neutral buffered) is the standard fixative. Tissue taken for histology should be fixed in formalin of a volume 20 times the volume of tissue. Tissues should be sliced thin - about 3 mm. Other dimensions are not critical; 3 x 3 cm is a convenient size. Larger pieces of tissue do not fix well.

Whole lesions, e.g. stomach ulcer, may be taken and fixed with good results as the wall of the organ is thin. When possible cysts and cavities in tissue, pus-filled lesions and fluid found in body cavity should be cultured for bacteria. Commercial holding media are excellent for the purpose, and their use is recommended. Special requests for research material such as whole organ preparations should only be honored if accompanied by detailed protocols.

Collection of Toxicology specimens

Tissue samples collected for pesticide and heavy metal analyses may be wrapped in aluminum foil or placed in plastic bags. For prolonged storage, glass containers with teflon-lined lids are recommended. The samples should be frozen as soon as possible, but may be transported on ice without significant loss of residues.

Samples of blubber, brain, liver, kidney and muscle should be collected routinely. Single assays may be performed with as little as 10-20 g of tissue, but samples weighing 200 g or more are necessary for a complete spectrum of analyses.

2. Parasite Collection

Parasites may be found anywhere within the body, but problem areas are identified as follows:

Head	- sinuses
	- ears
	- brain
Skin, Blubber	
Muscle, Fascia	
G. I. Tract	- including fecal sample
	- liver, gallbladder, duct
	- pancreas, duct
Respiratory	- major airways (opened)
	- lungs
Uro-genital	- kidneys
	- genital organs
	- ureters, bladder
Blood	- sample or smear

Fixatives

A - Alcohol-Formalin Acetic Acid (AFA) - 40 ml of 70% alcohol, 10 ml of 5% formalin, 2 ml of acetic acid, 48 ml of distilled water.

B - Glycerin-Alcohol - 5 ml of glycerin in 95 ml of 70% alcohol.

C - Potassium Dichromate - 2% aqueous

D - Formalin - 5% solution

E - Ethanol - 70% solution

Sampling Procedures

- subsample when large numbers are present
- do not distort
- ensure collection of head and tail
- sample portion of infected tissue when a parasite reaction is observed. Fix in A if possible.

- measure and photograph, when possible

1. Nematodes - fix in hot ($16^{o}C$, $60^{o}F$) fixative B.

   OR - place in tap water in cooler for 12 hours, then fix in solution A.

2. Trematodes, Cestodes, Acanthacephalans

   - place in tap water in cooler for 12 hours, then fix in solution A.

3. Lice, Mites, Copepods, Barnacles

   - fix in either D or E

4. Stool Sample

   - preserve in fixative C.

APPENDIX I

Individuals who have been proposed as members of ad hoc committees, and who were not in attendance at the Workshop are as follows:

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THE NATURE AND OCCURRENCE

OF

MARINE MAMMAL STRANDINGS

CETACEAN STRANDINGS ALONG THE COASTS OF THE BRITISH ISLES 1913-1977

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Abstract

In 1913, the British Museum (Natural History) started a stranded whale recording system which has been maintained continuously to the present day. To date over 2,200 records have accumulated, and represent well over 2,500 individual animals. Recently attempts have been made to identify the possible existence of trends in the numbers of strandings recorded and their significance. In order to demonstrate the various trends, the data have been grouped into 5 year periods for all species around the entire British coastline, and also in relation to the coast on which the individual animals were stranded. For this purpose the coastline has been divided into three separate areas, the eastern, southern and western seaboards. In addition, the individual species have been treated in a similar way and some of these are discussed to demonstrate trends and points of interest.

There is evidence to suggest that the frequency of strandings is related to the abundance of fish upon which Cetacea feed, which in turn is related to the natural resources of the sea. This correlation would also tend to suggest that there is some relationship between the numbers of strandings and the population density of Cetacea in the area. There is also evidence to show

that the stranding of cetaceans varies in distribution around the British Isles.

Introduction

Cetaceans stranded on the British coastline or caught in coastal waters have been the property of the Crown since a statute was enacted during the reign of Edward II early in the 14th century. They, together with the sturgeon, are termed "Fishes Royal". However in Scotland, the pilot whale, the bottle-nosed whale and any other species not exceeding 25 feet in length are not considered "Fishes Royal", nor are any cetaceans stranded on those parts of the coast where ownership has since passed from the Crown to the Lord of the Manor.

Sir Sidney Harmer, a former Keeper of Zoology and Director of the British Museum (Natural History), initiated a scheme whereby all records of stranded cetacea that come to the notice of the Receivers of Wreck or H.M. Coastguard are reported to this Museum. This scheme started in 1913 and continues today. Since 1913, over 2,200 stranding records representing 22 species have been accumulated (Tables 1, 2 and 3). Some 10% of these records are unidentified.

Methods

The data are held in the form of a card index from which most of the information for this paper has been extracted. Additional information from the stranded whale reports of Harmer (1914-27) and Fraser (1934-1974) has been incorporated.

TABLE 1 - All Cetaceans Stranded on the British Coastline 1913-1977

Species	1913 -17	1918 -22	1923 -27	1928 -32	1933 -37	1938 -42	1943 -47	1948 -52	1953 -57	1958 -62	1963 -67	1968 -72	1973 -77	TOTAL
Tursiops truncatus	11	13	10	23	21	20	15	15	21	17	28	9	14*	217
Balaenoptera acutorostrata	11	9	14	13	8	9	10	15	11	5	8	15	8*	136
Lagenorhynchus albirostris	9	12	15	6	14	3	4	5	5	4	12	14	13*	116
Hyperoodon ampullatus	14	3	5	4	5	12	4	6	5	4	6	9	6*	83
Grampus griseus	4	4	5	6	10	12	7	9	2	3	5	4	4*	75
Orcinus orca	1	3	6	2	2	5	7	0	3	2	7	6	4*	48
Lagenorhynchus acutus	3	3	4	4	3	2	1	2	1	1	6	4	7*	41
Ziphius cavirostris	3	4	4	4	5	0	1	1	1	2	7	4	1*	37
Balaenoptera physalus	8	11	6	3	0	1	4	2	0	1	0	1	0*	37
Mesoplodon bidens	3	0	1	2	1	3	1	4	2	4	2	4	2*	29
Physeter catodon	3	0	0	0	3	1	2	1	1	1	3	1	7*	23
Pseudorca crassidens	0	0	3	0	15	0	0	0	0	0	0	0	0*	18
Balaenoptera borealis	1	0	2	1	0	0	0	2	0	0	1	1	1*	9
Stenella coeruleoalba	0	0	0	0	1	1	0	0	0	0	0	1	1*	4
Balaenoptera musculus	1	2	1	0	0	0	0	0	0	0	0	0	0*	4
Mesoplodon mirus	1	0	0	1	1	0	0	0	0	0	0	0	0*	3
Monodon monoceros	0	0	0	0	0	0	0	2	0	0	0	0	0*	2
Kogia breviceps	0	0	0	0	0	0	0	0	0	0	1	0	0*	1
Delphinapterus leucas	0	0	0	1	0	0	0	0	0	0	0	0	0*	1

TABLE 2 - Three of the More Common Species of Cetacea Recorded on the British Coastline 1913-77

Species	Coast	1913 -17	1918 -22	1923 -27	1928 -32	1933 -37	1938 -42	1943 -47	1948 -52	1953 -57	1958 -62	1963 -67	1968 -72	1973 -77	TOTAL
Phocoena phocoena	Total	88	57	57	70	104	43	35	3	71	53	71	33	61*	779
	East	60	37	24	29	41	15	12	19	23	17	44	17	36*	374
	South	19	15	18	23	27	12	15	8	19	11	11	2	5*	185
	West	9	5	15	18	36	16	8	9	29	25	16	14	20*	220
Delphinus delphis	Total	19	18	20	9	29	11	10	6	5	6	4	15	28*	180
	East	3	4	1	1	10	1	4	2	1	2	1	3	-*	33
	South	10	5	11	6	16	2	4	2	1	1	1	8	13*	80
	West	6	9	8	2	3	8	2	2	3	3	2	4	15*	67
Globicephala melaena	Total	3	4	2	6	5	2	5	9	9	12	16	16	43*	132
	East	1	4	1	2	3	0	1	9	3	1	7	2	13*	37
	South	1	0	0	1	0	0	0	0	3	4	2	6	11*	28
	West	1	0	1	3	2	2	4	0	3	7	7	8	29*	67

(*Total number for 1973-76 plus average of those 4 years for 1977)

TABLE 3 - The Remaining Species of Cetacea Recorded from the British Coasts 1913-77

Species	Coast	1913 -17	1918 -22	1923 -27	1928 -32	1933 -37	1938 -42	1943 -47	1948 -52	1953 -57	1958 -62	1963 -67	1968 -72	1973 -77	TOTAL
All species (including unidentified)	Total	222	151	166	206	249	153	124	139	153	128	186	140	218*	2235
	East	110	73	60	75	104	60	53	72	49	46	90	59	65*	916
	South	58	32	41	58	65	30	32	28	33	21	26	21	45*	490
	West	54	46	65	73	80	63	39	39	71	61	70	60	108*	829

(*Total number for 1973-76 plus average of those four years)

Most strandings involve only a single animal, but on occasion two or more specimens are stranded; mass strandings are rare on British Coasts. In October, 1927 a school of approximately 150 false-killer whales (Pseudorca crassidens) stranded in the Dornoch Firth in north-eastern Scotland; and in May 1950, 148 pilot whales (Globicephala melaena) stranded in East Lothian on the east coast of Scotland (Fraser 1974).

For the purpose of this paper, each stranding is regarded as a single record, regardless of the number of animals involved. In some cases, the information received makes positive identification doubtful, but unidentified specimens have been included in appropriate parts of the analysis.

The data are subdivided according to the part of the coast on which the stranding occurred. The coastline has been divided into three separate parts; Fig. 1 shows the points of division. Records from the Orkney and Shetland Isles are included in those of the 'east coast', those of the Channel Islands and Isles of Scilly are included in the 'south coast', and Ulster records together with the Hebridean records are included in the 'west coast'.

The total length of the coastline, excluding Ireland but including all other islands, is approximately 8,800 miles of which some 6,000 are in Scotland (Fraser 1974).

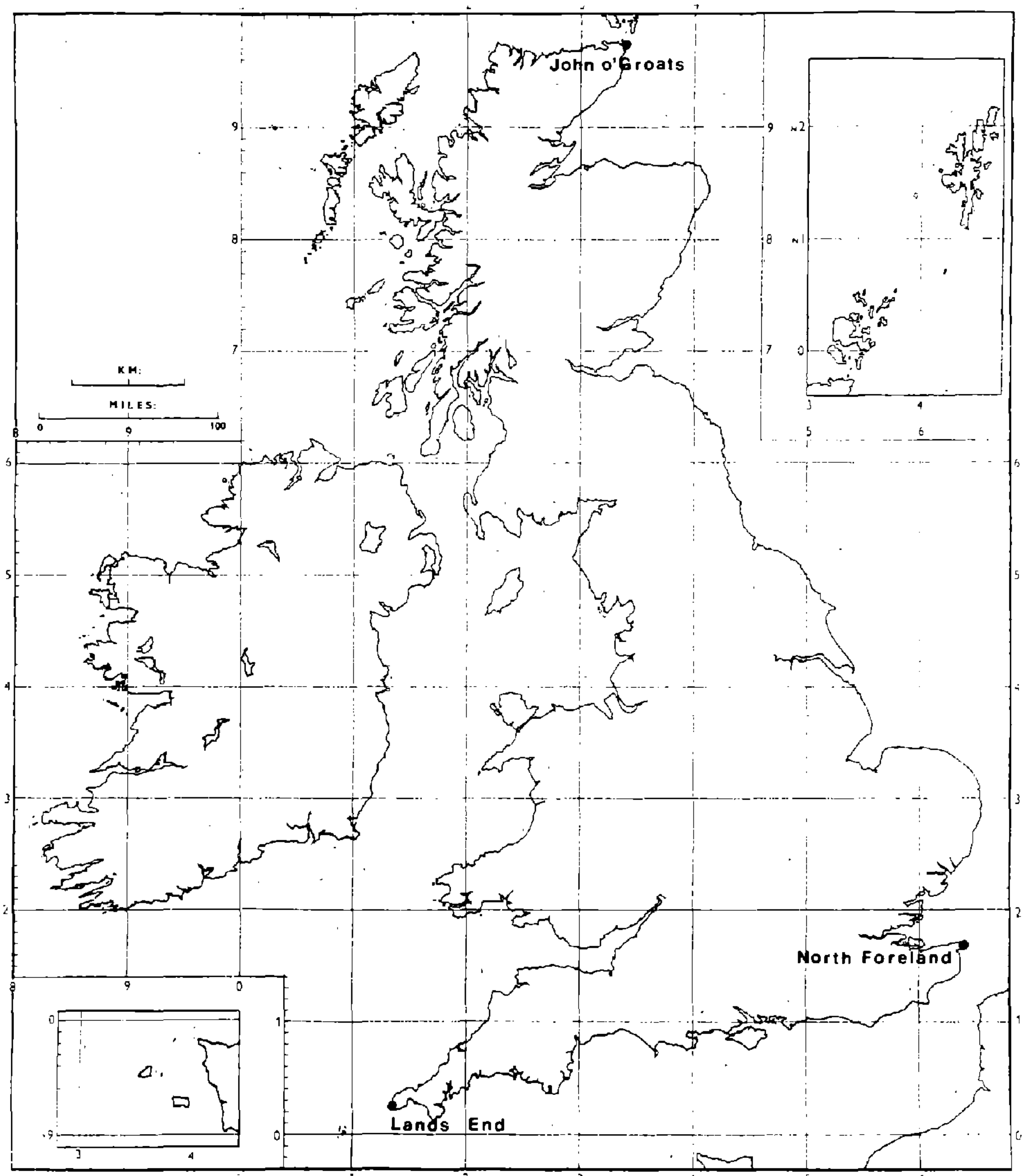


Fig. 1 Outline map showing three subdivisions of the coastline.

Results

Notes on the numbers of strandings up to 1972 have already been published (Sheldrick, 1976). This paper includes in addition figures for the quinquennium 1973-77, though the figures for the latter part are estimated from the average number for years 1973-76.

A. Total number of cetaceans stranded

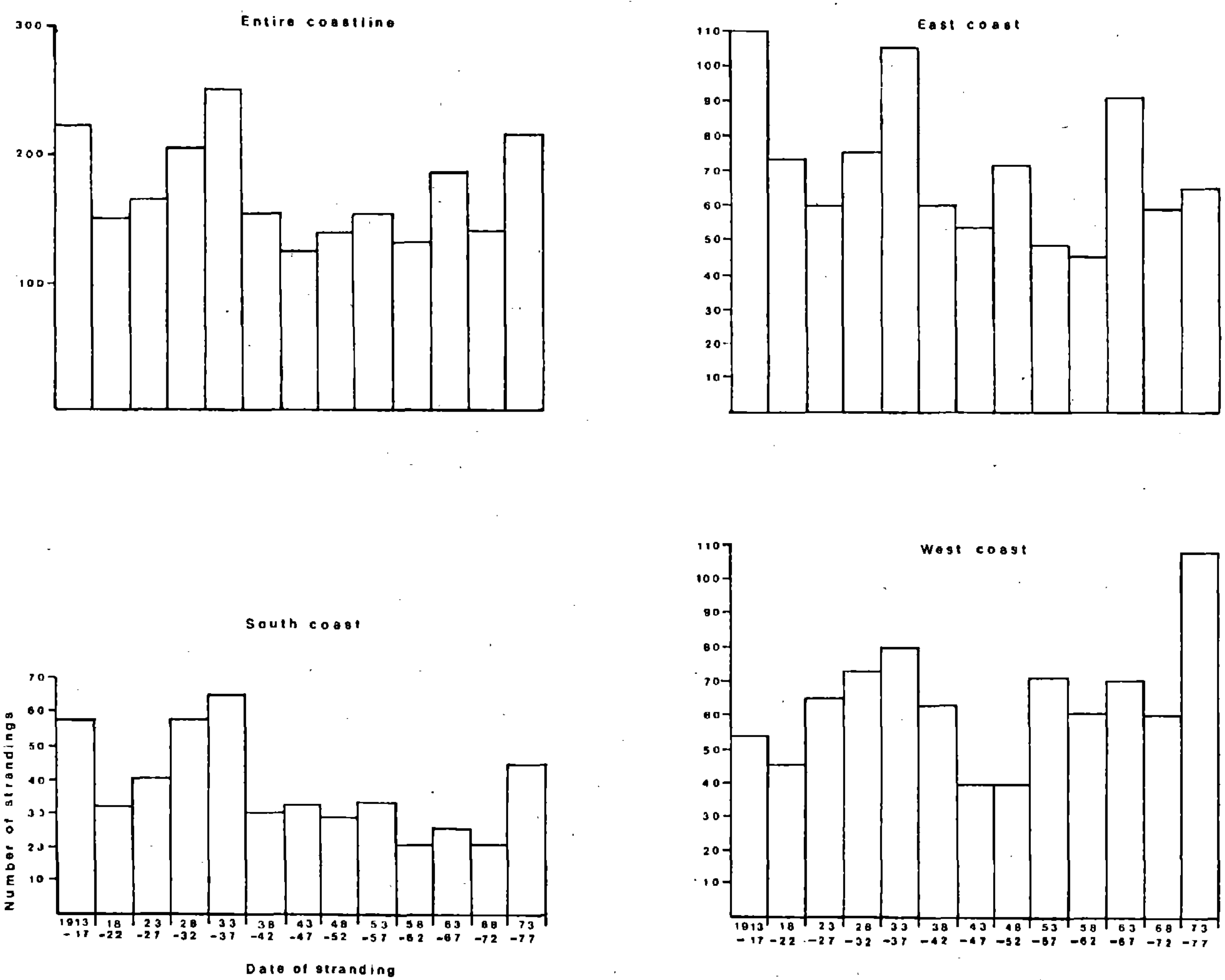
a. Total all-coast strandings

The number of strandings per quinquennium averages 172 (range 124-249) (Fig. 2a). One of the highest numbers of strandings occurred during the first period of the survey (1913-1917). The numbers then fell by about 25% and subsequently increased during the next three periods to reach a peak of 249 in 1933-37. There was then a drop of about 48% and numbers have fluctuated between 124 and 186 until the present quinquennium when the total is estimated to be 218, the third highest total since records began. The average figures for east and west coasts are comparable (70 and 64 respectively) whilst the average number of strandings on the shorter south coast is 38.

b. Total east coast strandings

The pattern of strandings on the east coast (Fig. 2b) reflects that for all coasts combined with peaks in quinquennia 1913-17, 1933-37 and in 63-67, but with little increase in the current period.

Fig. 2 Strandings of all cetaceans, 1913-77



c. Total south coast strandings

The pattern of strandings already noted was repeated on the south coast with peak numbers in 1913-17 and 1933-37 (Fig. 2c). However in 1938-42, there was a marked drop in strandings reported and the number gradually declined until the present quinquennium when the total rose to 45 - a rise of some 100% over the previous period.

d. Total west coast strandings

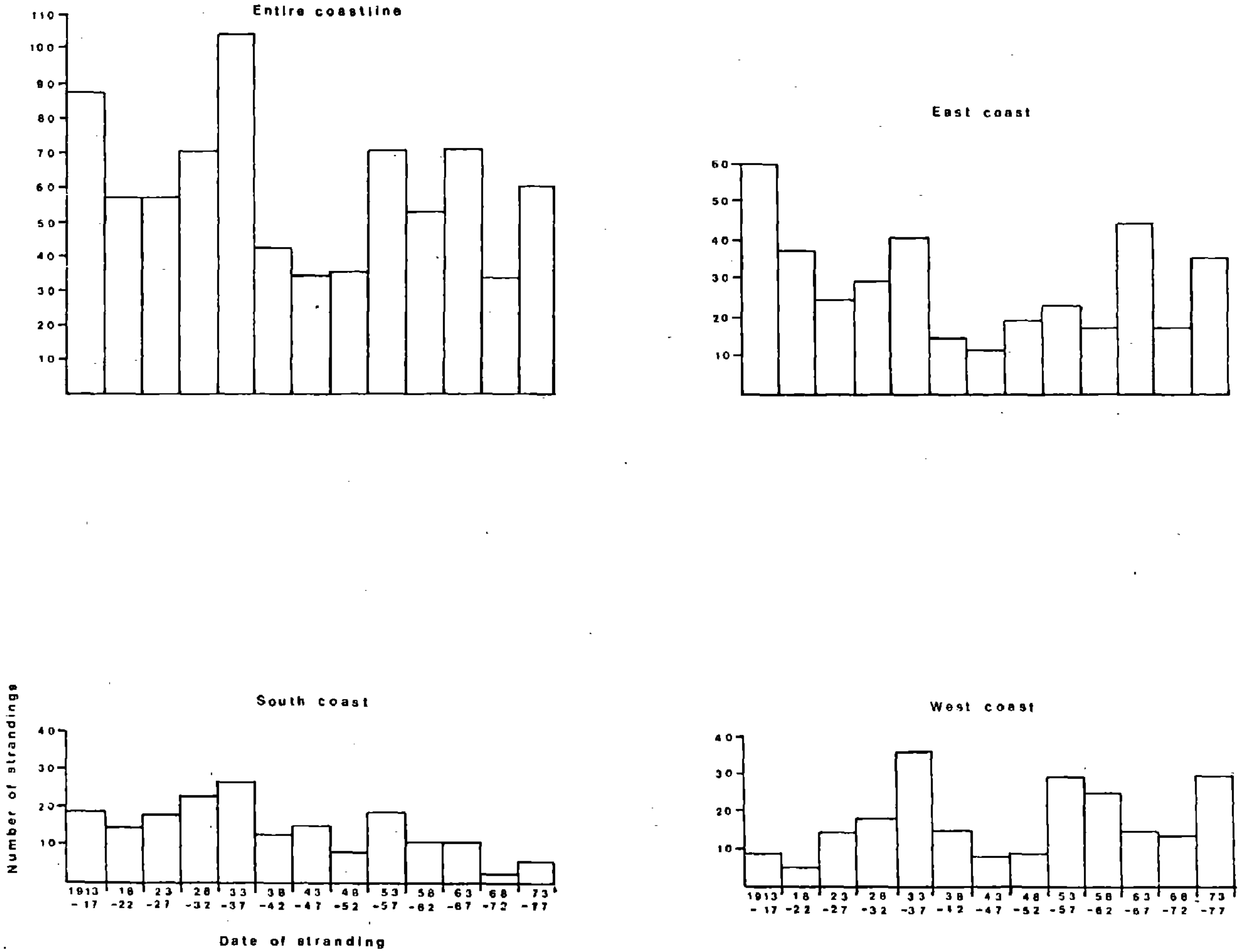
The number of strandings recorded on the western coast has been relatively stable (Fig. 2d). The peak of 1913-17 was less pronounced, and the high level attained in 1933-37 has been nearly maintained except for the decade 1943-52 when numbers dropped. During the current quinquennium, there has been a marked increase to a record figure of 108 strandings on this coast. There is thus a tendency for the numbers of strandings to fluctuate and some evidence that in some periods the fluctuations are synchronous in different areas.

B. Stranding records of individual species (Table 2)

a. Phocoena phocoena

The common porpoise *Phocoena phocoena* accounts for over 35% of total strandings, an average of 60 strandings per five year period. The records for this species follow the pattern of total strandings outlined above and although there is some fluctuation, there has been a tendency for the total number of strandings to decline, particularly on the south and east coasts. (Fig. 3)

Fig. 3 Strandings of the common porpoise, *Phocoena phocoena*, 1913-77.



b. *Delphinus delphis*

The numbers of common dolphin stranded are small, comprising only 8% of total strandings. The figures are subject to considerable fluctuation (Fig. 4) averaging around 20 per quinquennium during the first 25 years of the survey, less than 10 during the following 30 years, and 15 and 28 respectively during quinquennia 1968-72 and 1973-77. The increased figures for the last decade are almost entirely due to greater numbers being stranded on the south and west coasts.

c. *Globicephala melaena*

In contrast to the apparent decline in numbers of strandings shown by the records of the common dolphin, there has been a marked trend for the number of strandings of the pilot whale (*G. melaena*) to increase during the period of the survey (Fig. 5). This increase is particularly marked in recent quinquennia, and indeed in the current five year period, the 43 strandings more than double the record figures of the previous two quinquennia. Strandings of this species have fluctuated throughout the survey on the east coast, and most of the current increase is due to more numerous strandings on the south and west coasts.

Fig. 4 Strandings of the common dolphin, Delphinus delphis, 1913-77.

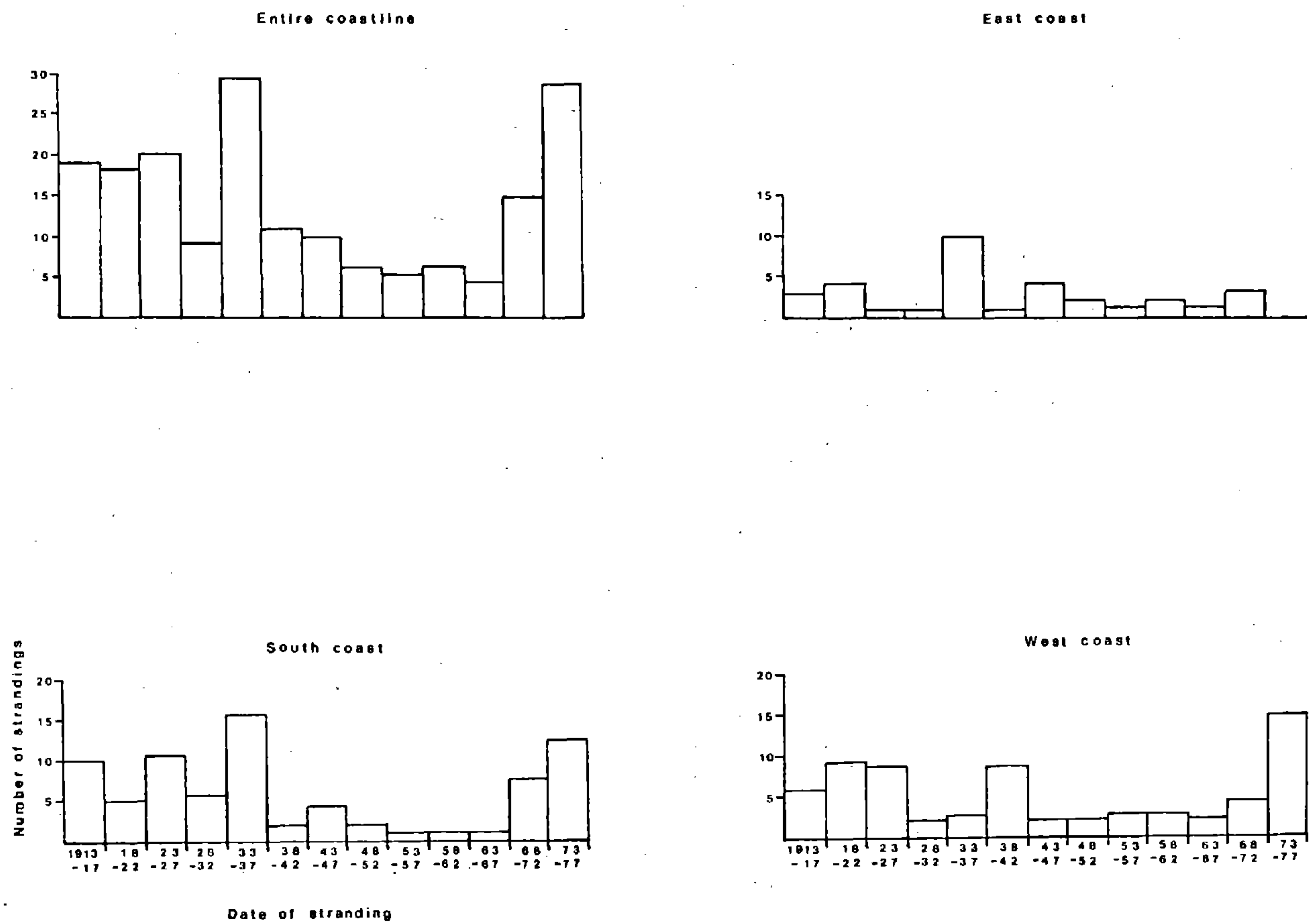
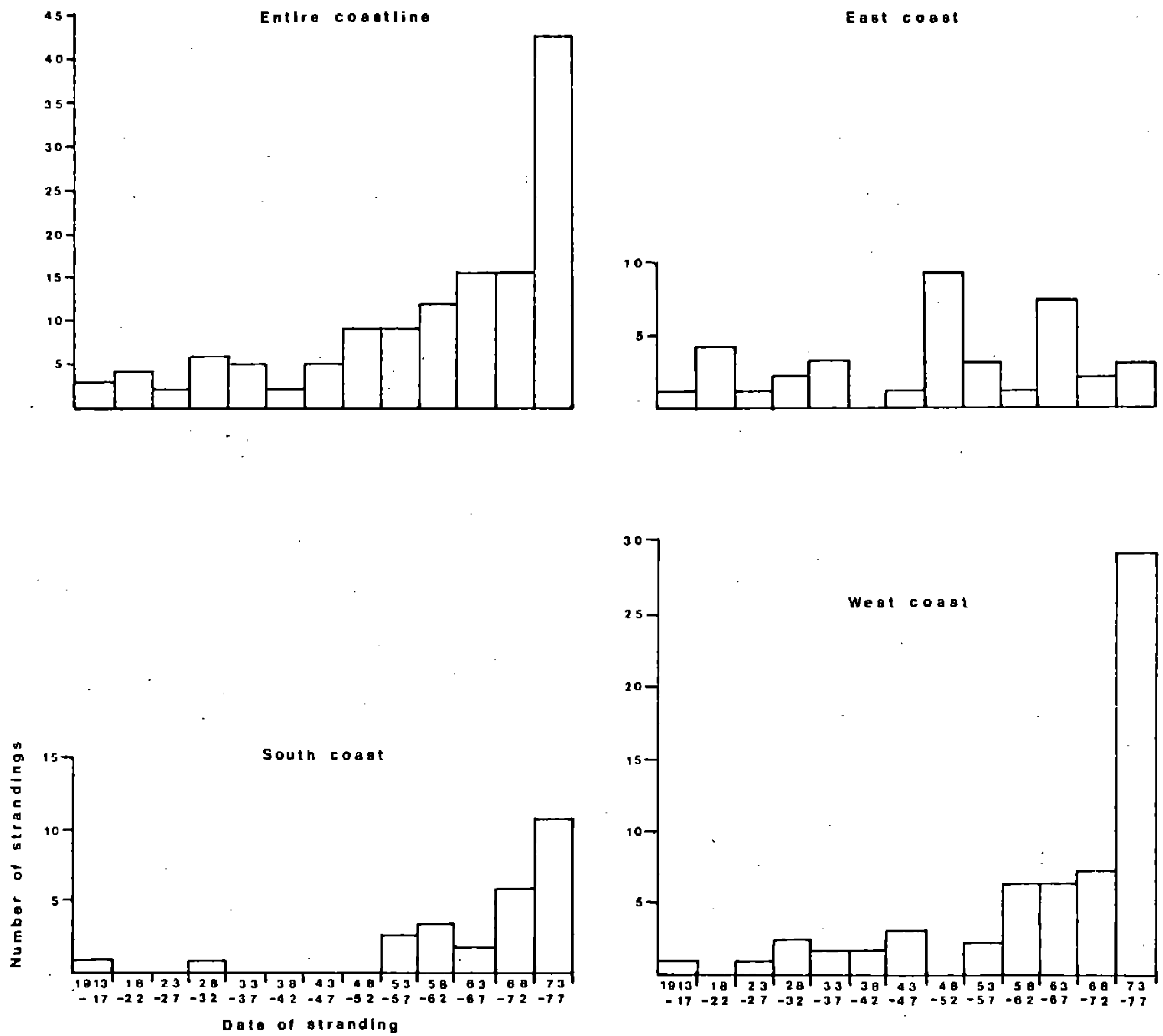


Fig. 5 Strandings of the pilot whale, _Globicephala melaena_, 1913-77.



These three examples illustrate the types of trends which can be recognized from the available data. The gradually declining number of common dolphin strandings, which have only recently recovered mainly on the southwest coasts, the fluctuation in numbers of records of the common porpoise on all coasts and the combined increase in numbers of strandings of the pilot whale and its apparent change in distribution.

Discussion

The reasons that live cetaceans come sufficiently close to the shore to strand are unknown. Disease has been postulated as a major factor in live strandings but this has yet to be confirmed. The British records suggest that many animals are dead before stranding, although live strandings are not uncommon particularly when multiple strandings occur.

The factors governing the number of strandings are also not yet clear. It is not possible to relate numbers of strandings to population density (Brown 1975). Investigations have been made into the literature concerning the concentrations of fish in British waters (Sheldrick 1976) and there is evidence that the population density of fish has varied considerably during the period under review. Russell (1930-73) and Corbin (1948-49) have provided detailed accounts of observations on the occurrence of planktonic stages of teleostean fish in the Plymouth area (W. English Channel) between the years 1927 and 1972 (Fig. 6) as well as information regarding adult stocks. Except for three species,

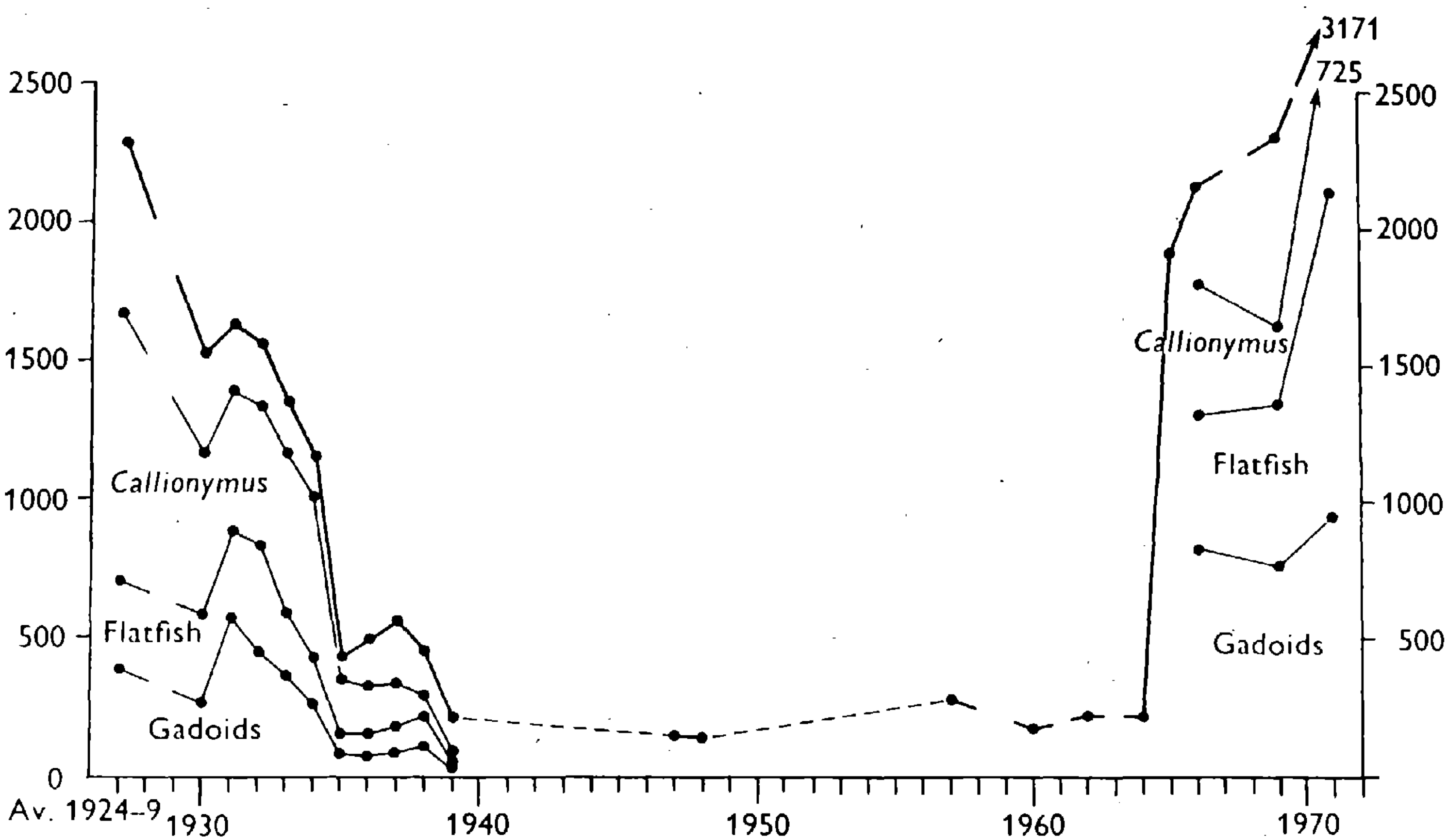


Fig. 6 The sums of the monthlyaverages of planktonic stages of teleostean fish, excluding clupeids, for those years for which data are available from 1924 to 1971. For the period 1924–9 an average figure for the 6 years in question is given. Sums of monthly averages are included separately for gadoids, flatfish, and *Callionymus* spp.

all young fish had been reduced by more than 75% by 1938, compared with the figures for 1930-34, and of these half were down to less than 10% (Russell, 1939), it was in 1938 that the adult stocks started to decline. These facts would tend to indicate that the reduction in planktonic stages was not necessarily due to an immediate geographical shift in the adult population but to a high mortality rate, possibly correlated with changes in the chemical composition and temperature of the water. In the spring of 1966, very large numbers were recorded and were higher than ever before. The catches increased until 1972 and since that year, they have remained high and are increasing further during 1977 (Southward, pers comm.). The general stranding pattern and that of the common dolphin on the south coast does appear to be related to the fluctuations in fish stocks outlined above, though other factors may also be involved. This same relationship is not so clear for the other two coasts. Bridger (1961) and Cushing (1966) have produced data on the occurrence of fish in the North Sea and describe the fluctuations of the different species. As the different species fluctuate independently, it is not possible to relate strandings to food supply owing to the lack of information on the food taken by Cetacea. Fraser (1934) notes that a large school of common dolphins was seen swimming off the coast of N.E. Scotland in 1933, coincident with an exceptional inflow of Atlantic water and plankton into the North sea. He also reported (Fraser, 1946) that in 1937 when there was an unusual invasion of the squid Todarodes sagittatus into the North Sea (Stephen 1937) common dolphins were again stranded in

comparatively large numbers, squid sucker marks being found on four of the stranded animals.

Thus food supply may be one of the factors influencing the number of strandings and their distribution, but very little is known about the food preferences of any of the species recorded.

It is possible that the increase in numbers of dead strandings of pilot whales on the southwest coasts is related to a concurrent increase in pelagic fishing in the area (Southward, pers. comm.). It may be that some of these animals are being caught in fishing nets and damaged before being returned to the water. Local fishermen in the area have reported an increase in the number of live whales sighted (Clark, pers comm.).

A number of factors require investigation; a gradual shift of geographical distribution, migration pattern or population fluctuations could all affect the numbers of strandings as could food preference or abundance.

Some species, for example, the pilot whale Globicephala melaena, the false killer whale Pseudorca crassidens and the sperm whale Physeter catodon all of which are open water species, seem prone to mass strandings perhaps because their behavior is adapted to deep water life and not survival in coastal waters. The effects of pollution have not been assessed.

Acknowledgments

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AN ANALYSIS OF CETACEAN STRANDINGS ALONG THE EASTERN COAST OF THE UNITED STATES

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Introduction

This analysis is based upon a total of 1078 records of stranded cetaceans from the Atlantic and Gulf coasts of the United States. The sample is essentially comprised of 3 subsamples. The first subsample consists of 538 records extracted from published sources. While it is not felt that this is exhaustive, it certainly includes the greater portion of these records and forms a usable sample. As time permits this sample is being slowly enlarged and updated by examination of relatively obscure literature sources. One major drawback of this sample is the reliability of species identifications, particularly for some of the more taxonomically complex groups of cetaceans. For example, in analyzing the distribution records of *Balaenoptera edeni* and *B. borealis* for another project, 38 percent of the records were found to be erroneous, and an additional 38 percent were unreliable or undocumented, leaving only 24 percent as usable records for critical purposes. It is ultimately hoped that the majority of the records in this sample can be confirmed through information provided in the original source or through unpublished records such as museum specimens.

The second sample consists of 198 records compiled during the first three years of operation of the Marine Mammal Salvage Program (MMSP) of the Smithsonian Institution. Virtually all of these records have been confirmed and most are represented by museum specimens. In addition, observation and recording effort were substantially greater and more uniform than they were for the published records.

The third sample consists of 342 records compiled during 22 months of operation of the Scientific Event Alert Network (SEAN) of the Smithsonian, in conjunction with continued efforts of the MMSP. This sample represents further intensification of observation and recording effort. Of these 342 records, 127 were derived from an intensive survey of the Outer Banks of North Carolina, from mid-December 1976 to mid-April 1977, which sampled what was probably an abnormal situation due to an unusually cold winter.

For purposes of this analysis, the sample consists of both those animals which stranded _sensu stricto_ (i.e., arrived at the beach alive and more or less under their own power, and were immobilized by surf and tide) and those which beached or drifted ashore dead. Although the factors and species involved are likely to be different, it is impractical to attempt to separate the two at this points, since it is commonly impossible to determine whether an animal was alive or dead when it arrived on the beach. The number of records in which the animals were known to be alive is indicated in table 1, but certainly represents a minimum estimate.

Table 1.
Stranding records for all species of cetaceans known to occur in U.S. coastal waters-Atlantic

	Published records			MMSP records			SEAN records			Total records		
	total records	total alive	mass strandings	total records	total alive	mass strandings	total records	total alive	mass strandings	total records	total alive	mass strandings
Balaena glacialis	11	--	--	2	--	-	1	--	-	14	---	--
B. mysticetus	--	--	--	-	--	-	-	--	-	--	---	--
Balaenoptera acutorostrata	25	2	--	9	1	-	6	1	-	40	4	--
B. borealis	3	-	--	3	1	-	-	--	-	6	1	--
B. edeni	4	1	--	2	1	-	1	1	-	7	3	--
B. musculus	7	-	--	-	-	-	-	-	-	7	---	--
B. physalus	61	4	--	7	2	-	7	2	-	75	8	--
B. sp.	7	-	--	2	-	-	-	-	-	9	-	--
Delphinapterus leucas	1	-	--	-	-	-	-	-	-	1	-	--
Delphinus delphis	29	1	--	8	2	-	7	-	-	44	3	--
Feresa attenuata	2	1	--	1	1	-	1	-	-	4	2	--
Globicephala macrorhynchus	75	37	35	3	3	3	9	4	2	87	44	41
G. melaena	13	5	1	7	1	-	5	3	-	25	9	1
Grampus griseus	5	2	1	2	-	-	5	3	-	12	5	1
Hyperoodon ampullatus	2	-	-	-	-	-	-	-	-	2	-	-
Kogia breviceps	55	9	-	33	16	-	20	11	-	108	36	-
K. simus	12	-	-	5	3	-	6	-	-	23	3	-
K. sp.	-	-	-	2	1	-	3	-	-	5	1	-
Lagenorhynchus acutus	2	-	-	8	4	2	8	3	-	18	7	2
L. albirostris	-	-	-	1	-	-	-	-	-	1	-	-
Megaptera novaengliae	9	1	-	5	1	-	1	-	-	15	2	-
Mesoplodon bidens	1	-	-	-	-	-	-	-	-	1	-	-
M. densirostris	6	1	-	4	1	-	-	-	-	10	2	-
M. europaeus	11	-	-	1	-	-	7	2	-	19	2	-
M. mirus	6	-	-	1	-	-	-	-	-	7	-	-
Orcinus orca	11	2	-	1	1	-	-	-	-	12	3	-
Phocoena phocoena	9	1	-	18	1	-	90	2	-	117	4	-
Physeter catodon	29	4	3	5	2	-	4	3	-	38	9	3
Pseudorca crassidens	10	2	2	-	-	-	5	2	1	15	4	3
Stenella coeruleoalba	8	2	-	12	3	-	8	5	-	28	10	-
S. longirostris	2	1	1	1	1	-	3	1	1	6	3	2
S. plagiodon	11	-	-	1	1	-	5	3	-	17	4	-
S. sp.	4	-	1	-	-	-	3	1	-	7	1	1
Steno bredanensis	4	2	2	-	-	-	1	1	1	5	3	3
Tursiops truncatus	59	3	-	35	3	-	125	-	-	219	6	-
Ziphius cavirostris	29	1	1	1	1	-	1	-	-	31	2	1
Unidentified dolphin	-	-	-	11	2	-	6	2	-	17	4	-
Unidentified whale	16	-	1	6	3	-	4	-	-	26	3	1
Totals	538	81	48	198	57	5	342	50	5	1078	188	59

Sampling biases

There is a complex of factors which determines whether a particular species of cetacean is likely to be found stranded on a given coastline. Those species which normally occur as part of the inshore fauna will be represented both by individuals which die in their normal area of distribution and are washed ashore, and by individuals which are ill or which stray for any of a variety of possible reasons and wind up as live stranded animals. Animals which do not normally occur inshore along a particular coast and which die in their normal area of distribution are not likely to be washed ashore largely due to the distance involved and the chance of scavengers or decomposition breaking up the carcass before it reaches the coast. In addition, virtually all cetaceans sink when they die, and while those which die in relatively shallow water are likely to refloat as decomposition gases buoy the carcass, those which die in deep water will remain on the bottom since hydrostatic pressure will keep the gases in solution and prevent refloating of the carcasses. Thus these species will only be represented by those individuals which stray from their normal distribution pattern and die on or near the coast.

Both the size of the population in a given area and the mortality rate will contribute directly to the relative abundance of a particular species in the stranding record. These may both be subject to seasonal variation, resulting in regular changes

in the relative abundance of strandings. The interaction of these two factors may well be responsible for some otherwise apparently anomalous patterns in the stranding record. For instance, a primarily offshore species which has relatively low population levels, but has regular inshore movements coincident with an increase in mortality, may be represented by more records than a much more common species with an opposite pattern of either movement or mortality. In addition to the factors affecting the distribution of the strandings themselves, there are a number of subsequent influences affecting the stranding record. Once an animal has stranded, it has to first be noticed, second be reported, and third have the report recorded. Large animals, particularly the great whales, are much more likely to be noticed and reported than are are small ones, as are unusual appearing animals, such as adult male beaked whales with prominent tusks. Once brought to the attention of a naturalist, rare or unusual animals are much more likely to be recorded than are those which are considered common. The result is that past records are most likely to be relatively complete for the large whales, followed by rare and unusual species, and least complete for common or rare but unimposing species. It is this combination of circumstances which results in there being eleven published records of Mesoplodon europaeus, but only nine of Phocoena phocoena.

Species composition

Of the 35 species of cetaceans known to occur in the North Atlantic Ocean, 33 have been recorded as stranding on the eastern coast of the United States. As a rough approximation, those with fewer than 10 records can be taken as representing extra-limital strays (table 1). This accounts for 11 species, one of which (Mesoplodon mirus) is known primarily from this area and should probably not be considered a stray. The 25 remaining species represent the normal, or at least regularly occuring cetacean fauna of this area. This group accounts for 96 percent of the stranding records. Of these, 12 species with greater than 20 records account for 77 percent of all records and can be considered as common elements of the coastal fauna. The five most common species (greater than 50 records), Balaenoptera physalus, Globicephala macrorhynchus, Kogia breviceps, Phocoena phocoena, and Tursiops truncatus, comprise 56 percent of all records and probably represent the regular members of the inshore fauna.

Tursiops truncatus and Phocoena phocoena, with totals of 219 and 117 records respectively, are the commonest elements of the coastal fauna. Other distribution records indicate that both of these species normally occur near shore in relatively large numbers and are certainly the dominant cetacean elements in these areas.

The third most abundant species, Kogia breviceps (108 records) is somewhat surprising, as this is usually considered to be a

relatively rare, offshore animal. In part this high number of records may have been due to a tendency in the earlier records for this species to be more frequently reported because of its unusual appearance. However, if one considers only the SEAN sample, it is still the third ranking species (20 records as opposed to 125 for *Tursiops* and 90 for *Phocoena*). If the sample from the Outer Banks survey is deleted (50 *Tursiops* and 61 *Phocoena*) as representing a combination of unusually high effort and abnormal mortality, the relative abundance of *Kogia breviceps* becomes even more striking (20 records versus 75 for *Tursiops* and 29 for *Phocoena*). This almost certainly represents a much greater relative abundance of this species than has been thought to be the case. It is also quite likely the result of an inshore movement of part of the population during a period of increased natural mortality, resulting in a somewhat disproportionate number of strandings.

The next species in order of relative abundance are *Globicephala macrorhynchus* and *Balaenoptera physalus*. These are both apparently not inshore species, but are probably represented in the western north Atlantic by relatively large populations. In the case of *B. physalus*, there is some indication of a predominance of strandings in the spring, probably representing a northward migratory movement through inshore waters at that time. Useful sighting records of these species are few, but anecdotal information from local fishermen suggests that they are relatively common offshore throughout the year.

Records of the remaining species are too few to permit anything

to be said about their relative abundance. Their distribution as stranded animals is indicated on table 1. A few comments are necessary for the records of some of these species, for which there seem to be extenuating circumstances, affecting the apparent abundance and distribution.

The records for Balaenoptera acutorostrata are complicated by a preponderance of incidental entanglements in fishing gear. This seems to be particularly true of juvenile animals and is most common in the Cape Cod area. This species is apparently susceptible to entanglement in fixed gear, commonly fish traps or weirs. In many cases adults can apparently penetrate the gear and escape, but juveniles are trapped and drown. Whether this represents purely accidental entanglement, or whether this species is attracted by concentrations of fish which represent a possible food source, is unknown.

The entire group of Balaenoptera species presents problems of identification, particularly when the records are based upon decomposed remains or partial specimens. It is quite likely that many of the records presented in the literature as B. physalus actually represent other species. Until such time as these can be verified, conclusions based upon them must be taken as tentative. In addition a number of records for this species and for Balaena glacialis, particularly in the Cape Cod area, may represent drift whales lost from fishing activities. There was an early steam whaling industry which operated out of Provincetown around the turn of the century, and which seems to

have been responsible for a number of records of beached animals. In cases where this was obvious, these records have been excluded from consideration.

A somewhat analogous problem exists for early records of mass strandings of *Globicephala melaena* in the Cape Cod area (particularly in the vicinity of Wellfleet). A very poorly documented, but apparently extensive drive fishery for this species existed in this area and was certainly responsible for large numbers of pilot whales being on the beaches. To what extent these were drives of schools that might have otherwise have stranded is unknown. Only one of these records is documented in the literature and appears to be a genuine stranding. There is a considerable body of information in unpublished records which is yet to be analyzed.

Many early records of *Globicephala macrorhynchus* probably represent strandings of *Pseudorca crassidens*. The differences between the two are evident enough to anyone familiar with cetaceans, but the literature formerly available to the general biological community was nearly unusable for many species, resulting in most strandings of large, black cetaceans being referred to *G. macrorhynchus*. Most of those that were recognized as pilot whales were referred to *G. melaena*, as general recognition of the distinctions between the two species has only recently occurred. There appear to be no valid records of *G. malaena* below Cape Hatteras, so any pilot whale records south of there have been interpreted as *G. machrorhynchus*.

A comparable problem exists for _Delphinus_ _delphis_ and _Stenella_ _coeruleoalba_. These two species are frequently confused, and since _S._ _coeruleoalba_ is the lesser known of the two, the identification is more likely to be given as _D._ _delphis_.

Live strandings

From a practical standpoint it is useful to have some idea of the incidence of live strandings. Seventeen percent of all records involved animals known to be alive at the time of stranding. Twenty eight percent of these were mass strandings involving a number of individuals. Of species with a relatively large (greater than 20) sample size, _Globicephala_ _macrorhynchus_ had the highest percentage of live strandings (50%). _G._ _melaena_ and _Stenella_ _coeruleoalba_ were next with 36%, and _Kogia_ _breviceps_ was fourth ranked with 33%. Of the large whales, _Physeter_ _catodon_ was most commonly found alive. Twenty-four percent of the _Physeter_ strandings were live, and 33% of these were mass strandings. The commonest baleen whales, _Baleanoptera_ _acutorostrata_ and _B._ _physalus_ had 10 and 11 percent live strandings respectively. It is most interesting to note that all of the species with a high incidence of live strandings are apparently offshore forms, while the two most abundant inshore species, _Tursiops_ _truncatus_ and _Phocoena_ _phocoena_ had extremely low incidences of live strandings (3%). This is consistent with the viewpoint expressed earlier, that one would only expect to find stray individuals of offshore species, which are likely to wander onto the beach and be found while still alive. The very low

incidence of live strandings of inshore species suggests that these are generally more capable of avoiding the beach while alive, even though they may be terminally ill or injured.

Mass strandings

There are records of a total of 64 mass strandings of ten species. Of these, 6 records are fairly clearly groups that fragmented and restranded from a larger stranding nearby, leaving 58 as a more reasonable total. *Globicephala macrorhynchus* was by far the commonest species involved, with 41 records, representing 69% of all mass strandings and 48% of the records for this species. The total number of individuals involved in these mass strandings was 1118, giving a mean of 28 individuals per stranding. This is certainly a minimum estimate, as many of the strandings appear to have been only partially reported. Mass strandings of this species fairly clearly divide into two sizes, those on the order of 100-150 individuals and those on the order of 10-15 individuals, probably representing different types of social groupings. Mass strandings of this species were concentrated in Florida (23), and to a lesser extend Georgia (9), with a range from Louisiana to North Carolina. The records occurred throughout the year, with no indication of seasonality.

Of the other species, only *Pseudorca crassidens* could be considered as regularly mass stranding. Although this species is currently only represented by three mass stranding records, it is likely that a fair number of the early records for *G. macrorhynchus* were actually *P. crassidens*.

Stenella longirostris, *Stenella* sp., and *Steno bredanensis* are the only other species for which mass strandings represent a significant portion of the total records. *Globicephala melaena*, *Grampus griseus*, *Lagenorhynchus acutus*, *Physeter catodon*, and *Ziphius cavirostris* have been occasionally known to mass strand along this coast.

Geographic distribution of strandings

The sample chosen for examination of geographic distribution is the group of SEAN records from Florida to Maine, for the period 1 October 1976 through 31 May 1977. This sample is probably as close as we can get to a uniform recording effort at the present time. The anomalously large sample of 61 *Phocoena phocoena* from North Carolina was excluded as it appears to be outside the normal range of this species and is almost certainly the result of unusual weather conditions. This leaves a total of 211 records of cetaceans, distributed as follows:

FL	GA	SC	NC	VA	MD-DE	NJ	NY	CT-RI	MA	ME-NH
40	4	4	76	20	3	12	7	5	27	13

Three clear areas of geographic concentration are obvious here: Florida, North Carolina-Virginia, and Massachusetts-Maine. Equally clearly, these are the result of areas of concentrated effort. Florida has a long history of marine mammal activity and has almost certainly more recorded strandings than any other state. It also has the longest coastline of any of the eastern states. The North Carolina-Virginia concentration represents the area of primary activity of the MMSP, and the Massachusetts-Maine peak

represents the work of the New England Aquarium and a number of other groups active in that region. There is every reason to believe that had this level of effort been maintained along the whole coast, a much higher total records would have resulted. Taking a rough estimate of the stranding density along the NC-VA coast (0.2 per mile for this period) and multiplying this by an equally rough estimate of the total coastline (3000 miles, including both coasts of Florida), we can arrive at an estimate of the total expected number of strandings, which is about 600 for the period, or a mean of 30 per month.

This estimate is based substantially on two assumptions, first that the stretch of coastline chosen is representative of the entire coast, and second, that the sample is a reasonable approximation of the total number of strandings in that area. There are few data which can be brought to bear on the first assumption. Without attempting a rigorous analysis, it seems that the few strandings which are reported from these areas are largely derived from limited stretches of coastline where there happens to be active surveillance (i.e., most of the records are from the same few localities). We could certainly expect a much higher number of records if this level of activity were extended throughout these areas. While this does not directly demonstrate the validity of the first assumption, it does improve its tenability somewhat.

A close examination of the North Carolina-Virginia records indicates that 57 of the 96 records (59%) are from the period mid-December 1976 through mid-April 1977, when the MMSP was

conducting an intensive survey along the Outer Banks of North Carolina. This is an average for that area of 14 strandings per month, based upon a survey of about half the total coastline. It this rate is extrapolated through the entire 20 month period, we would have expected a total of 280 records for this area alone. As noted later, there is no reason to believe that this rate represents a seasonal high. It would therefore appear that the sample of 76 from NC-VA is probably an extremely conservative estimate. As an academic exercise, if this rate (14 per month) were representative of the entire coast, we would have expected approximately 100 stranding per month for the entire area, or 2000 for the period covered.

In any case, the four months survey of the Outer Banks area successfully demonstrated the hypothesis under examination, which was that if you actually go out and look, you will find substantially more than if you stay home and push paper. Diligent application of this principle to the entire coastline may well result in records approaching 100 per month.

Temporal distribution of strandings

The same geographic area (Florida to Maine), and the period 1 May 1976 through 30 April 1977 was chosen for an analysis of seasonal distribution of strandings. Plotted by month, the records are as follows. Again, the large *Phocoena* sample from North Carolina was omitted.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
8 (3)	22 (15)	28 (8)	13 (10)	17	8	5	8	6	9	4	8

The figures in parentheses represent the sample after deduction of records directly attributable to the MMSP Outer Banks survey. While this indicates no seasonal peaks, it is probably that such peaks would be noticeable along any given section of coast if the sample were large enough. It is difficult to demonstrate with the present data, but there seems to be a tendency for a greater number of winter records in the more southerly areas and summer records in the more northerly areas. This may well, however, be influenced by seasonal fluctuations in effort. The whole question of temporal variation will be assessable only after compilation of extensive survey data.

Abstract

MARINE MAMMAL STRANDINGS IN THE SANTA BARBARA CHANNEL REGION FROM 1975 TO 1977

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The Santa Barbara Museum of Natural History has been actively engaged in monitoring and salvaging marine mammals in Santa Barbara and Ventura Counties since the fall of 1974. The coastal region represents a floral and faunal break between northern and southern species and there is a relatively diverse array of marine mammal species. Our salvage program provides an indication of marine mammal populations present, their reproductive condition, feeding habits, and causes as well as rates of mortality over seasons.

Data sheets following Scheffer (1967) and Norris (1961) are used. The program operates in close cooperation with California Fish and Game; they provide information on strandings as do park rangers, County agencies, and the public. The Museum cooperates also with National Marine Fisheries Service, Bureau of Sportfisheries and Wildlife, University of California, and California Polytechnic San Luis Obispo, to name a few. We have agreements to collect and ship fresh tissue samples and swabs to 12 investigators. A field number assigned to every specimen also is recorded on the Marine Mammal Reports filed with California Fish and Game and National Marine Fisheries Service, thus anyone reviewing these reports may access the data file for a given specimen.

California sea lions predominate. In 1977, calls on this species have averaged about 2 per week, and in relation to other species, we do not have resources to observe and measure each one. About half of all animals reported are fresh, i.e., dead no longer than 30 hours. Nearly all fresh California sea lions and all other species are necropsied either in the field or the Museum. Necropsies include analyses for parasites and stomach contents. The Museum's study collection contains skeletons, hides, tissue, organs, stomach contents and parasites.

Average annual numbers for the program to date are 43 Zalophus californianus and 10 Phoca vitulina. About equal numbers, i.e., 3 to 4 per species per year, of Mirounga angustirostris, Enhydra lutris, Eschrichtius robustus, Phocoenoides dalli, Lagenorhynchus obliquidens and Delphinus delphis have been noted. Other species recorded are Lisodelphis borealis, Balaenoptera acutorostrata, Grampus griseus, Phocoena phocoena, Orcinus orca, and Callorhinus ursinus. These latter species have stranded at a rate of one or less per year.

Strandings recorded are nearly all dead specimens, but there are exceptions. Porpoises may strand alive and die in an hour or two. For pinnipeds, normal haul out behavior must be considered. Their occurrence is noted because they haul out infrequently on the mainland shore of the Channel. Considering the large numbers in the Channel Island, we may see a trend of increased numbers on the mainland. Many harbor seals received are pups. During the first half of 1977, 9/16 were pups and 5/16 were rehabilitated and returned to known harbor seal hauling grounds. Many Zalophus

that haul out are emaciated, congested, and lethargic. In some cases these have been observed to gradually weaken and die. Starting in 1977, the Museum has been working closely with a local rehabilitation program and records have been kept of sick or injured *Zalophus* as well as dead ones; 26/53 animals recorded during the first half of 1977 have been sick or injured (2/26 injured).

Based on a relative small data base over 14 species, strandings appear to be related to disease, old age, or human related injury. In many cases, precise cause of death is not evident.

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Abstract

STRANDINGS OF GRAY WHALES IN WASHINGTON STATE

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Strandings of dead gray whales (Eschrichtius robustus) have been documented since Scammon's first observations and description of the mammal in his work in 1874. Accurate data collection on such strandings has, however, been only a recent development. Records on stranding occurrences and notes on material examined or collected are frequently incomplete, inaccurate, or unobtainable. Within the last four to six years, efforts have been made to better substantiate strandings and record pertinent information, primarily a result of an increase in public awareness about these marine mammals and the establishment of federal policies favoring careful and thorough study on the status of their population.

During the first six months of 1977, four California gray whales were found beached on the Washington coast. Recent records for Washington and Oregon, based on material from the National Marine Fisheries Service and the Smithsonian Scientific News Alert Reports, show that for the years 1974 through 1976, Washington recorded two strandings of dead gray whales (both occuring in 1974) and Oregon recorded four (two in 1974 and one each for 1975 and 1976). California, with its greater coastal range, has averaged six strandings per year.

The Washington specimens consisted of two sub-adult males, measuring 7.32 meters and 8.26 meters, and two adult females, measuring 11.71 meters and 13.13 meters. The first animal (7.32 m. male) appeared 1.6 km south of Ocean City, Washington (47°02'N., 124°10'W) on 31 January, 1977. On 20 February, 1977 the second animal was reported and was found beached at North

Cove, Washington (46°43'N., 124°03'W) at the entrance to Willapa Bay. This animal was the 11.71 meter female and was lactating at the time of death. A third specimen (8.26 m. male) was transported to Chinook, Washington on 1 March, 1977 by a gill-net fisherman after the animal was found entangled in his net. All evidence indicates that this animal was dead prior to its appearance in the net. The net was set 8.0 km upstream in the Columbia River (46°15'N., 124°00'W). The fourth and final specimen was the 13.13 meter female and was found washed ashore 8.0 km north of Long Beach, Washington (46°25'N., 124°03'W) on 12 May, 1977.

Photographs, notes on external appearance, ocean and weather conditions for the period of time just preceding the beaching, location, date, length, sex, reproductive condition were recorded on all four specimens. A complete series of external measurements was obtained for animals one, three and four. The complete skeletons of the two males and the skull and left flipper of the North Cove female were collected and prepared. A thorough post-mortem examination was made on the Chinook male and included weights and measurements of all major internal organs. An examination was performed on the first male as well, but due to the advanced stage of decomposition, no measurements or tissues were taken. The two females were also at advanced stages of decomposition and an extensive analysis of the viscera was not undertaken. Tissues for pesticide level analysis were collected from the two males and are currently being processed.

Data collected on specimens 2 and 3 allow us to speculate on the probable cause of death. The lactating female had a severely fractured skull at the left temporal region, showed evidence of a propeller slash on the ventral peduncle, and the flukes were completely severed from the body. Such injury indicates collision with a large vessel in the heavy traffic channels of

this region of the Washington coast. The Chinook male weighed only 3325 kg, less than a young male gray whale of comparable length (8.53 meters as compared to our animals 8.26 meters length) that was stranded in San Francisco Bay in 1961. Dale Rice has reported a mean blubber thickness for northward migrating immature males of 12.6 centimeters ($\pm$.2 cm) with the range from 9.5 cm to 16.0 cm. Maximum blubber thickness on the Chinook animal was 6.4 cm with an average of 4.8 cm. Such evidence indicates severe emaciation. Sightings of a single gray whale in the same vicinity by fishermen for a period of two weeks prior to this animal's entanglement in a net, indicates that it may have been in the region of the Columbia River for an extended period of time. The overall effects of a fresh-water environment on this marine species are difficult to assess but adequate or proper food supply could be one of many factors leading to the death of this animal. The remaining two whales were decomposed and cause of death remains unknown.

Recent observations of gray whales in Puget Sound and British Columbia, as well as stranding location and dates indicate that individuals may not follow a strict migratory pattern, and may occur at "odd" times along the coast of northwestern United States and western Canada.

PINNIPED AND SIRENIAN BEACHINGS

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Introduction

Historically, beached pinnipeds and sirenians have been a source of natural history material for the opportunistic investigator. However, as the habitats of these animals have become restricted and their populations reduced, these animals have taken on a new value as a research resource, and efforts have been itensified to recover and examine every available specimen. Live and relatively fresh specimens are especially important for investigations into naturally occurring diseases and other natural history data.

For the purpose of this paper we shall review briefly the activities in four geographic areas: Northeast (New England), Southeast (Florida), Southwest (California) and Northwest (Washington and Oregon).

Northeast

The early efforts in the New England area were concentrated on the rehabilitation of live beached harbor seals, Phoca vitulina concolor. Various institutions along the coast have contributed to this effort including Woods Hole, Sealand of Cape Cod, the Aquarium of Cape Cod, the Provincetown Aquarium, and the New England Aquarium in Massachusetts, the Mystic Marinelife Aquarium in Connecticut, Aqualand in Maine, and the University of Rhode Island.

Three years ago the New England Aquarium began requesting that all beached seals be brought to its attention so that statistics could be compiled and, in the case of fresh carcasses, causes of death could be investigated. The recovery of nine animals in 1974, 31 in 1975, 61 in 1976, and 44 in the first six months of 1977, reflect the increased effort and awareness of the value of these specimens, as well as an increased cooperation within the New England region.

In the last 54 months, over 150 beached harbor seals have been examined at the New England Aquarium. The majority of these animals was recovered along the New England coast from Cape Cod to the Canadian border. A few animals also have been recovered in Rhode Island and Connecticut. Approximately 50% were recovered alive; many were parasitized with lung worms (Otostrongylus circumlitus), heart worms (Dipetalonema spirocauda), and seal lice (Echinopthirius horridus) which in heavy infestations causes matting of the hair with blood, leading in some cases to erroneous reports of seals that have been hit by boats or clubbed on the head. The remainder of the recovered live animals were malnourished orphaned pups. Of the seals recovered alive, 13 have survived.

A rough analysis of the beachings indicates a seasonal southward migration from Canada, Maine and Massachusetts, and there is no sexual bias. Very few mature animals seem to strand; those specimens available have been animals killed incidental to fisheries survey work (drowned in census nets).

All carcasses are surveyed or necropsied depending on the state of decomposition. Gross pathology has been done on over 80%, with histology on over 50% of the animals. In all cases, tissues are taken for pesticide, hydrocarbon and heavy metal analysis.

The animals in New England are recovered with the assistance and cooperation of the National Marine Fisheries Service and the various states involved.

Southwest

On the West Coast there are five pinniped species whose ranged extend and overlap from Alaska to Mexico: the California sea lion (*Zalophus californianus*), the (northern) elephant seal (*Mirouga angustirostris*), the harbor seal (*Phoca vitulina*), the northern fur seal (*Callorhinus ursinus*), and the Stellar sea lion (*Eumetopias jubatus*). The western coastline differs from the East in several ways. Principally, the major populations of animals inhabit offshore islands, and are therefore inaccessible. The major thrust of the work on beached pinnipeds in California focuses on attempts to rehabilitate live animals, the majority of which are yearlings and young of the year that have been separated from their mothers.

Only a few investigators have been retrieving carcasses for necropsy and thus a cross-sectional analysis by age is not possible. However, some indication of the total number of retrieved carcasses can be obtained by reviewing the reports made to the State of California by the various

disposing agencies. These reports are forwarded to the National Marine Fisheries Service's Marine Mammal Coordinator at Terminal Island, California.

The Santa Barbara Museum of Natural History has been salvaging marine mammals in Santa Barbara and Ventura Counties since the fall of 1974. Their program helps to identify the presence of marine mammal populations, reproductive condition, feeding habits, and causes and rates of mortality. The average annual numbers of pinnipeds to date are 43 California sea lions, 10 harbor seals, and three or four elephant seals.

In the last 54 months, more than 518 live pinnipeds have been recovered in Southern California, primarily by Marineland of the Pacific, the Naval Undersea Center, and Sea World of San Diego. Of these, 379 were California sea lions, 82 northern elephant seals, 47 harbor seals, nine northern fur seals and one ringed seal, Phoca hispida. An analysis of recoveries over this period does not reflect an annual increase as in New England. However, the State of California had taken an active role in the management of its marine mammals before the Marine Mammal Protection Act of 1972, and the major institutions involved have been recovering beached animals for many years.

In June 1975, a new institution, the California Marine Mammal Center, was established in Marin County just north of San Francisco. In its first 26 months of operation, it has recovered 82 live animals: 38 California sea lions (10 still alive), 21 northern elephant seals (eight still alive), 19 harbor seals (eight still alive) and four northern fur seals. The number of animals has increased each year with six in 1975, 33 in 1976 and 41 in the first seven months of 1977. Most of the rehabilitated animals have been released.

The majority of the juvenile animals recovered in California suffers from terminal debilitation brought about primarily by parasitism with lung worms (_Parafiaroides_ sp.). Death usually results from parasitic pneumonia. Seal pups orphaned shortly after birth suffer primarily from nutritional deficiency.

Northwest

Only a few institutions work with stranded marine mammals in the northwest. Oregon State University has been performing autopsies on retrieved pinniped carcasses since January 1974. These include Stellar sea lions (_E. jubata_), California sea lions (_Z. californianus_), harbor seals (_P. vitulina_), and the northern elephant seal (_M. angustrostris_). Other institutions involved in retrieving pinnipeds are the Puget Sound Museum of Natural History, the Seattle Aquarium, and the National Marine Fisheries Service.

Although the Pacific Northwest is a rich area for marine mammals, not as many pinnipeds are retrieved due to the rugged nature of the coastline and the relatively low rate of inhabitance. It is believed that the random surveillance efforts do not come close to reflecting the potential number of pinniped strandings in this area.

Southeast

Some distinction should be made between "beaching" in pinnipeds and sirenians. Pinnipeds are amphibious and those recovered alive often return to the beach if placed in the water. Sirenians, on the other hand, are helpless on land and are generally recovered dead, trapped or injured and disabled.

The West Indian manatee (_Trichechus manatus_) has been salvaged historically by the major oceanariums in Florida. Manatees have been

identified as an endangered species as well as being covered by the Marine Mammal Protection Act of 1972. In 1974, the University of Miami and the U.S. Fish and Wildlife Service began to salvage all trapped, injured or dead manatees. H.W. Campbell (U.S. Fish and Wildlife Service) organized a statewide manatee reporting network primarily through the Florida Marine Patrol. Most dead manatees are now reported to the Fish and Wildlife Service's Gainesville office.

In the last 42 months, about 157 manatees (four alive) have been salvaged; there have been reports of dead animals that were never recovered. The salvaged carcasses have been concentrated in three areas: Meritt Island, Dade County, and the Caloosahatchee-Peach Rivers. This distribution of recoveries is partly due to the distribution of the manatees, but uneven reporting has not been ruled out.

About 50% of the mortalities of manatees are clearly caused by human activity(flood control dams, boats and barges). It is easy to document boat kills, swallowed fish hooks and bodies crushed in flood control gates, even in badly decomposed animals. The extent of the natural mortality in the remaining animals has been difficult to determine. The biggest problem relates to the rapid decomposition of carcasses in a tropical environment. This makes difficult the even simple tasks of getting organ weights, total body weights, and examination of reproductive organs. Uniformity of reporting is ensured by the small number of cooperating investigators as well as the use of standard data sheet.

In spite of the efforts expended on beached animals, a considerable amount of data is not being gathered. The major thrust in working with beached animals has been to rehabilitate live animals. The existing programs were initiated with this goal in mind. If we are to maximize the

collection of data, more effort must be directed toward the recovery and necropsy of carcasses in order to gain deeper insights into natural history, acquire research materials, and assess habitat modification in order to promote the continued survival of wild and captive populations.

STRANDING FACTORS,

CIRCUMSTANCES, AND THEORIES

Abstract

BRAIN ABSCESSES, FLUKES AND STRANDINGS

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Ridgway and Johnston (1965) reported unidentified ova from the brain of a beached common dolphin (Delphinus). Subsequently Ridgway and Dailey (1972) examined seven beached Delphinus finding extensive areas of cerebral necrosis, abscessation and trematode ova in all cases. Johnston and Ridgway (1969) also found trematode in the brains of two Tursiops truncatus and two Lagenorhynchus obliquidens. One of the Lagenorhynchus was found swimming aimlessly in a harbor and the other died after two weeks in captivity exhibiting very unusual behavior patterns. The abscesses from Tursiops were found in newly captured animals from Mississippi Sound. In both Tursiops cases, the affected areas were small, and flukes (Nasitrema sp.) were found in the nasal sinuses, a common finding in this species (Ridgway, 1965).

In all of these early cases, only ova were found in the brain. Whole flukes (Campula sp.) were not found in the brain but were present in the bile ducts. This led to the suggestion that ova from the flukes in these abdominal areas were somehow reaching the brain. This is probably possible through the vertebral system which is the major blood supply to the brain in dolphins. The vertebral veins could serve as a route of fluke or ova movement since tumor metastasis and air emboli have been shown to move through these veins in man (Batson, 1957).

In more recent cases, one Delphinus was found with a whole fluke in the

right ventricle of the brain. This fluke was identified as <u>Nasitrema</u> species. Since 1963, I have examined 15 single stranded <u>Delphinus</u> from Southern California beaches. All of these had fluke ova with extensive abcessation of the brain. One case exhibited a large cyst in addition to fluke ova and abscesses. It is argued from these cases at least that brain abscesses resulting from trematode infestation contribute to stranding.

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THE ROLE OF PARASITES IN MARINE MAMMAL STRANDINGS ALONG THE NEW ENGLAND COAST

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Background

Neary 600 stranded marine mammals have been examined in varying detail, over a 5 year period, as part of an overall stranding network sponsored by the New England Aquarium. These represent 4 mass strandings, two of *Lagenorhynchus acutus*, two of *Globicephala melaena* and one of *G. macrorhynchus* (Florida) totaling 350 animals. The remaining animals, 92 odontocetes, 6 mysticetes, and 130 pinnipeds, stranded or were beached as individuals.

Findings

Parasites are a prominent feature in nearly all strandings. In some cases, they are associated with significant organ damage, so much so that it is tempting to relate their presence to the actual stranding event, either directly through associated disease, or indirectly through the ability of a relatively harmless parasite to overwhelm a host in the face of stress.

In a 1973 to 1977 survey of 25 harbor porpoises, *Phocoena phocoena*, only 5 of which were alive when beached, 24 specimens had lung worms, *Pseudalius inflexus*, *Stenurus minor*, *Torynurus convolutus*, and *Halocercus invaginatus*. In some instances the numbers of larger nematodes in the main-stem bronchi seemed limited only by their own density. There is always some pathology associated with the worms, and almost invariably a diagnosis of verminous pneumonia is made. Ironically, these nematodes can be found in large numbers in healthy, robust, free-living harbor porpoises (Arnold and Gaskin 1975). Though this tends to weaken the parasite-stranding association, there is an occasional inoculum of firm data to support it. In one of two cases in which lung worms have been found in the heart and pulmonary arteries, *P. inflexus* in the right atrium was found to be associated with vegetative valvular endocarditis and thrombosis, the probable cause of death.

Hepatic trematodiasis is another common finding in *Phocoena phocoena*. The trematode *Campula oblonga* is associated with marked biliary fibrosis, hyperplasia, and necrosis. In some cases, it appears that 15% or more of hepatic tissue is replaced by reactive connective tissue containing tortuous tracts in which can be found trematodes and their associated debris. The condition is widespread, having been found in 16 of 19 livers examined, and has also been reported in harbor porpoises from European waters (Andersen 1966). It is

doubtful that uncomplicated hepatic trematodiasis is, in itself, sufficiently debilitating to cause an animal to strand. This feeling is based solely on morphological assessment of the condition, and not on any biochemical lesions which might result from metabolic or excretory products of the trematode.

Campula oblonga also causes marked pancreatic damage, apparently through migration from the hepatopancreatic duct into the pancreatic duct. The trematodes cause severe chronic pancreatic fibrosis and, to a lesser extent, pancreatitis. The condition is almost universally found in animals which have hepatic trematodiasis. In typically advanced cases, the pancreas is small, firm, nodular and, on cut section, oozes thick, dark brown fluid containing trematodes and their ova. It is clear that in some cases, damage is sufficiently extensive so as to impair organ function, perhaps vitally so. In my judgement, pancreatic trematodiasis due to Campula oblonga is more of a potential threat to health than the hepatic condition, and may well be responsible for the eventual series of events which lead to Phocoena strandings. Similar but less severe pancreatic lesions are associated with the trematode Oschmarinella laevicaecum in the Atlantic white-sided dolphin, L. acutus.

Parasite invasion into the brain does not seem to be a common occurrence in strandings along the New England coast. Focal necrotizing encephalitis, of parasitic origin, has been found in one of three common dolphins, Delphinus delphis. The

lesion contained triangularly shaped ova similar to those described by Ridgway and Dailey in 1966 for the same species along the coast of California. It is doubtful that the ova originated from hepatic or pancreatic trematodes as neither organ was apparently parasitized; the pterygoid sinuses were not examined for Nasitrema sp., the trematode which similarly shaped ova, and which is now considered to be the invading organism. Examination of brain lesions in L. acutus, one of which was certainly associated with aberrant behavior and probably with the stranding, was suspiciously similar in nature, but did not reveal the presence of parasites or eggs.

Few, if any, of the remaining parasites found in odontocetes can be regarded as a threat to health, though not for want of trying by new media. Stenurus globicephala, a nematode of the head sinuses and lungs in L. acutus and other species, is a parasite in question.

These small worms, measuring up to 27 mm in length, first appear in weaned calves, and by the time the dolphin is an adult, as many as 3300 can be found densely clustered in the cranial sinuses, eustachian tubes and the middle ears. In one case, a nematode was observed penetrating the round window of the inner ear - a potentially critical site.

This parasite was first described by Baylis and Daubney in 1925, and later, Wesenberg-Lund (1947) reported its presence in a single L. acutus stranded in Roskilde Fjord, Denmark. No quantitative estimates of the worm appear in the literature;

this is rather surprising in view of their seemingly critical location. Fraser (1966) was the first to suggest that such nematodes might be responsible for some strandings, through disruption of the "essential organs of hearing ". "Stenurosis is a widespread disease among dolphins and, undoubtedly, causes them great damage ", states Delyamure (1955) referring to data on 37 Black Sea dolphins, Phocoena phocoena, which he and his colleagues found to be infected with a related nematode, Stenurus minor. Animals with heavy ear infestations apparently respond poorly to noise, causing the Crimean dolphin fishermen to describe them as "deaf" (Azov dolphins that do not respond to the telephone).

It is virtually impossible to ascertain whether such reports are more poetic than scientific. Certainly every adult Phocoena phocoena, L. acutus and G. melaena which strands along the New England coast is infested with Stenurus sp. There is no evidence that the worms functionally damage the middle or inner ears, at least by their physical presence. They do elicit a chronic low grade inflammatory response in the sinusoidal mucosa, but this hardly seems sufficient in the present context. It has yet to be determined whether a hyperallergenic response to their presence, or whether their metabolic or excretory products might permeate the round window and thereby affect sensitive inner ear structures. Despite the nearly total lack of such information, the popular press, with some unwitting assistance by the scientific community, has

ascribed a profound role for these parasites in the stranding phenomenon.

Our information yield with regard to the role of parasites in mysticete strandings is rather appalling. Most of the carcasses we have examined have been in an advanced state of decomposition, with the exception of a single minke whale, Balaenoptera acutorostrata, which fell victim to boat collision, and a fresh-beached finback whale, Balaenoptera physalus, which could not be examined in detail.

The most common pinniped along the New England coast is the harbor seal, Phoca vitulina. In a 4 year survey of 94 strandlings, 72% ranged between 80 and 109 cm, a sub-adult population. Thirty percent of the seals had lungworms, Otostrongylus circumlitus, 43% had heartworms, Dipetalonema spirocauda. There was a mixed infection of heartworm and lungworms in 26% of the animals.

Otostrongylus are rather large nematodes. They partially occlude the major airways, and are often associated with congestion and pneumonia. It is difficult to assess whether the worms are primary offenders or simply overwhelm seals already debilitated by starvation, injury or disease. The same holds true for heartworms. Resolution of the question regarding the precise effects of these parasites depends upon quantitative estimates of parasites in healthy wild-caught seals, and physiological monitoring of infected animals in captivity.

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Abstract

INDIVIDUAL STRANDINGS OF SMALL CETACEANS ALONG SOUTHERN CALIFORNIA BEACHES

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During the four year period 1970-1973, detailed data on 81 individual strandings of small cetaceans were collected. These strandings occurred along the 153 kilometer section of southern California coastline extending from Leo Carrillo State Beach (Los Angeles County) to Huntington Beach (Orange County). Seven species were examined: common dolphin, *Delphinus delphis* (48); Pacific white-sided dolphin, *Lagenorhynchus obliquidens* (19); northern right whale dolphin, *Lissodelphis borealis* (7); striped dolphin, *Stenella coeruleoalba* (1); bottlenose dolphin, *Tursiops* sp. cf *gillii* (1); short-finned pilot whale, *Globicephala macrorhynchus* (1); and Dall's porpoise, *Phocoenoides dalli* (4).

Fifty-seven (70%) of these cetaceans were recovered in a relatively fresh condition. Extensive necropsies were performed to determine the cause of stranding. In addition to life history data, tissues for histopathological study were preserved for analysis. Detailed accounts of degree of parasitism and gross tissue changes were also made.

Parasite data were presented by Dailey and Walker (1978). They suggested that many of the strandings may have been the result of trematodes, _Nasitrema_ spp. in the air sinus, inner ear complex, and central nervous system. Nematodes, _Crassicauda_ spp., were only involved in the air sinus and inner ear pathology to a minor extent. Separate reports are in preparation on the life history data (Walker, Ms.) and the histopathological findings (Cowan _et al._, Ms.) from these small cetaceans.

This study on small cetacean strandings is the most comprehensive performed in the study area. The background information regarding stranding frequency, location, parasitism, and related pathology is designed to provide baseline data for future assessment of small cetacean strandings in this area.

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ECOLOGICAL ASPECTS OF CETACEAN STRANDINGS

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Abstract

Using the northern pilot whale *Globicephala melaena* in the northwest Atlantic as an example, it is shown that strandings - whether of singletons or mass strandings - occur in proportion to the abundance of a species. They are thus an expression of its natural mortality rate. Further, for fin whales stranded at Britain, stranding rate, as an expression of natural mortality and proportional abundance, can be used to demonstrate how whaling had affected the abundance of the species. The long time series of strandings at Britain can also be used to demonstrate that the abundance of a number of delphinid species has changed with time, though the causes of such population fluctuations are unknown. Recently in the waters near Holland, disappearance of two inshore delphinids has been associated with human disturbance and pollution, though the exact causation is not clear.

Introduction

I shall discuss two subjects. First, what do strandings of Cetaceans represent? In other words, how can we relate the

distribution and abundance of well-known species in relatively well-known areas to their occurrence as stranded animals. From this approach we can, I think, gain some idea of the agencies that bring about the death of individuals or groups.

Second, I am interested in the feedback; what are some of the biological features of stranded animals in the aggregate. These may tell us something about the fortunes of their populations in the vicinity, and something about their life history characteristics.

For these approaches I have used-first hand data available to me from cruises in eastern Canadian seas. However, because the historical record here is very poor, I have turned to the much more extensive data available in the literature for European coasts, and particularly the famous series of British strandings which now extends over more than 60 years.

Pilot whales (*Globicephala melaena* Traill) in the northwest Atlantic.

Four cruises in which I have taken part (Table 1) range in space from George's Bank, New England to Hamilton Inlet Bank, Labrador, and from July through December. Pilot whales were seen on all voyages and were the most numerous Cetacean encountered overall, being absent only from inshore Labrador waters in early summer.

If the sightings of *G. melaena* made on these cruises and reported to me by others are plotted (Fig. 1), the species is seen to be numerous in the region: George's Bank, Scotian Shelf, outer Laurentian Channel and Grand Bank. It occurs

Table 1. Aggregated sightings of Cetacean individuals observed on four research cruises in the western North Atlantic.

Ship	Investigator II	A.T. Cameron	Sackville	Trident	Totals
Year	1957	1959	1960	1968	
Dates	July 30- Aug 8	July 9- July 22	Oct 19- Dec 1	Aug 3- Aug 11	
N. Lat.	47^{o}-55^{o}	43^{o}-47^{o}	$32^{o}30'$-46^{o}	40^{o}-44^{o}	
W. Long.	44^{o}-55^{o}	50^{o}-47^{o}	65^{o}-74^{o}	69^{o}-59^{o}	
G. melaena	10	20	31	244	305
D. delphis	20	2	83	86	191
P. phocoena	3		1	9	13
L. albirostris	18				18
L. acutus		10	25	10	45
T. truncatus			30	12	42
B. physalus	2		3	7	12
B. acutorostrata	3				3
Megaptera		7	5	4	16
B. borealis ?			1	9	10
B. musculus ?				2	2
Physeter				10	10

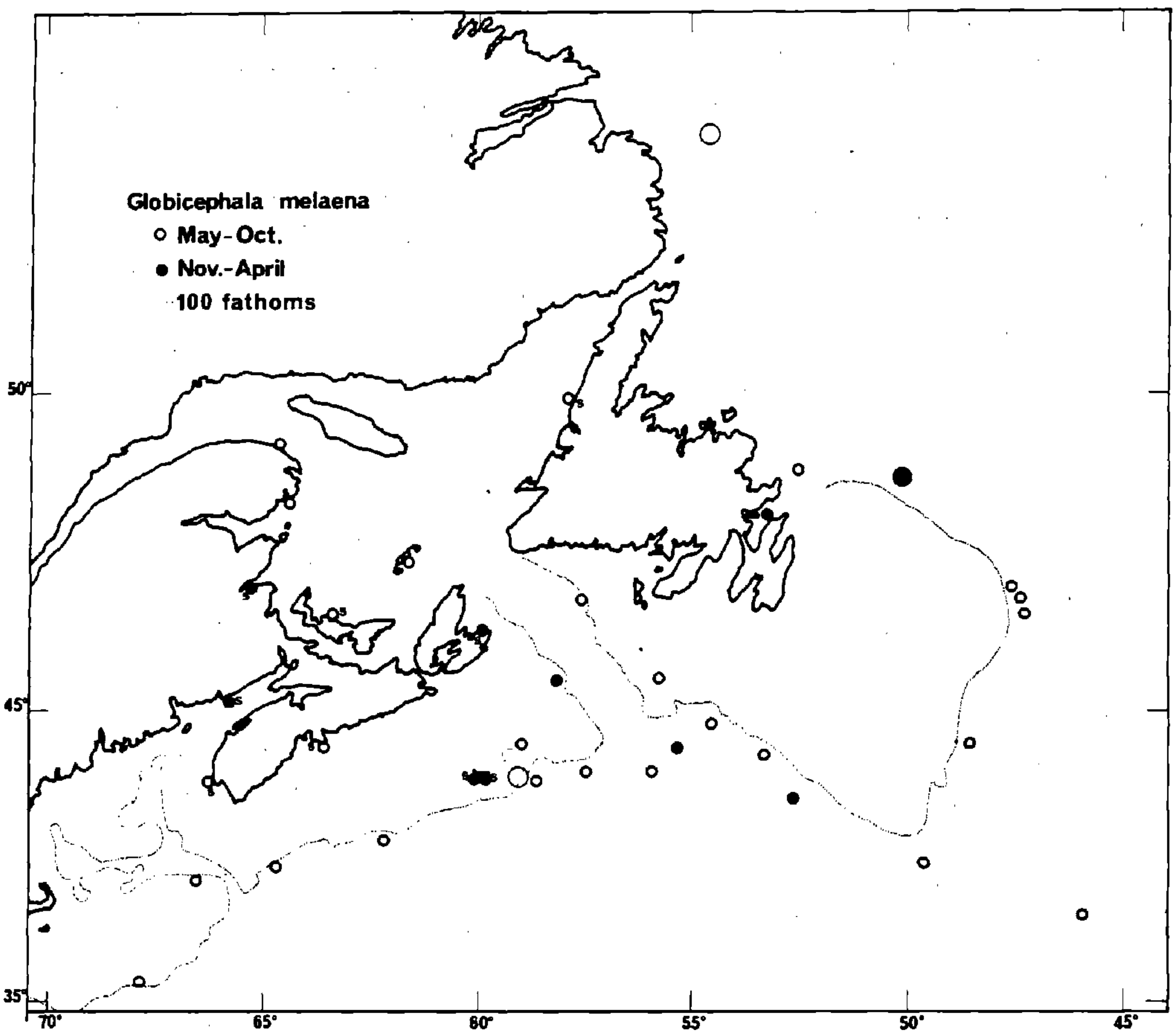


Fig. 1 Records and strandings (s) of Globicephala melaena in the northwest Atlantic, 1957 to 1973.

here along the Continental slope at all seasons, and enters the colder waters over the Shelf during the hydrographic summer.

Sable Island ($43^{o}57$'N, $59^{o}50$'W) lies near the outer border of the Scotian Shelf, in a region of "Slope Water" mixing cold coastal water and that originating from the North Atlantic Drift. It is a sand island 50 km long, with spits extending at each end. Consequently, it traps a fair variety of cool water Cetacea, dead or alive. Since 1957, with increasing intensity up to 1966 and, thereafter, once or twice yearly, the Arctic Biological Station has sent teams to study the resident gray, Halichoerus grypus, and harbour seals, Phoca vitulina, on this island and to maintain property. As a second task, they have monitored the accumulated strandings since previous visits by patrolling the two beaches with a tractor. Results up to 1968 were reported by Sergeant, Mansfield and Beck (1969). Additional records reported up to date give the total shown in Table 2. (These include a multiple stranding of pilot whales investigated by Geraci and St. Aubin 1977). Globicephala meleana is the most common species stranded, whether as singletons or as multiple strandings. Note that a group of live-stranded Stenella coeruleoalba managed to free itself (Sergeant, Mansfield and Beck 1969).

What are strandings? - Fin whales in eastern Canada and at Britain.

It is now time to examine just what strandings represent. The choices would seem to be:

Table 2. Known incidences of Cetacea stranded at Sable Island ($43^{\circ}57'N$, $59^{\circ}50'W$) 1958-1976.

Species	Number of strandings		
	Single	Multiple	Total
Balaenoptera physalus	1		1
B. musculus	2		2
Rorqual, indet.	2		2
Hyperoodon ampullatus	2		2
Kogia breviceps	2		2
Physeter catodon	1		1
Phocoena phocoena	3		3
Orcinus orca	1		1
Globicephala melaena	11	2[1]	13
Lagenorhynchus acutus	3		3
Stenella coeruleoalba	3	1[2]	4
Delphinus delphis	1		1

[1] 18 and 120 animals.

[2] three animals which escaped. All other records are of animals which died.

1. Natural mortality
    a. Natural accident
    b. Morbidity, including that caused by disease
2. Human mortality
    a. Wounding by hunting
    b. Human accident (boat propellers, etc.)

I shall assume that mass strandings (of Globicephala, Physeter, etc.) must represent natural accidents since either simultaneous morbidity or simultaneous wounding seem highly improbable. Single strandings could be the result of any of the four categories above. However, considering natural mortality as a cause, singletons investigated on the beach seem nearly always to be diseased and rarely survive re-launching; natural accident to singletons seems therefore to be rare. The distinction between natural mortality and death or wounding by human agency is often difficult to determine directly, few stranded animals being found in a fresh state. However, one may tackle the problem indirectly, as by comparing stranded distribution with that of human activities which might produce dead or wounded animals. I give as examples, knowledge of fin whales in the Gulf of St. Lawrence and at Britain.

Fin whales are rather common in the Gulf of St. Lawrence and are frequently found dead on its extensive coasts, often to the embarrassment of those who must keep clean the beaches. One special category here is of whales stranded by ice in early spring (see Sergeant, Mansfield and Beck 1969 for some examples). Others are found on down-current beaches and may have died of

natural causes or from collision with a ship. Very recently, two fin whales were reported stranded near Sept Iles, Quebec at the same date (25 June 1977) and one almost certainly had tangled with a ship's propeller. We can recreate the circumstances from local information. There was a heavy run of capelin (Mallotus villosus) attracting fin and minke whales close to shore. Sept Iles is a busy port handling bulk cargoes of iron ore. Fin whales do not clear their movements with human traffic controllers...I submit that this kind of hazard will increase in the future as whale populations recover and, being unexploited, will remain at equilibrium levels. Whales may also tangle (literally) with fishing fleets as reported to me also in the Sept Iles region for minke whales and shrimp draggers. For porpoises, entangling in nets is already known as an important, world-wide phenomenon.

I turn now to a historical set of data, that of the occurrence of stranded fin whales around Great Britain. The set of records of strandings around British coasts cover the time period 1913 to 1966 (Harmer 1927, Fraser 1934, 1946, 1953, 1974) and 1973 (Purves MS 1974). A more useful tabulation by decades up to 1972 has been provided for small Cetacea (minke and smaller) by Brown (1975) but, unfortunately, this does not cover the large species.

Using these data, I studied the number of strandings of fin whales in relation to those of other species (Table 3 from Sergeant 1976). I also considered the data on catch per effort (CPE) of fin whales at land station in the Hebrides between 1924

Table 3. Strandings of all Cetacea and of fin whales at Britain, 1913 to 1966 by survey periods and in 1973. Data from Harmer (1927), Fraser (1934, 1946, 1953 and 1974) and Purves (MS 1974).

Years	1913-1926	1927-1932	1933-1937	1938-1947	1948-1966	1973	1913-1947
Number of years	14	6	5	9	9	1	35
Total, all species	407	186	216	220	507	33	1,043
Fin whales:							
percent total	5.1	1.1	-	2.2	0.6	-	2.9
rank order	6	13	-	10	14	-	8

and 1929, when whaling ended. The rank order of fin whales at Britain declined from 6th to 13th place among stranded species between median years 1920 and 1930, while CPE declined from 71.6 whales per boat in 1924 to 18.6 whales per boat in 1929. Therefore, strandings in Britain declined at the same time as availability of fin whales to catcher boats at the Hebrides.

Fin whales at Britain did not increase beyond rank order 10 in subsequent years up to 1966, in spite of negligible catching in Britain, which occurred only at the Hebrides in 1950 and 1951. I took this to mean that the population of fin whales in British seas remain depressed because of heavy pressure on fin whale stocks in adjoining seas, certainly in the Faeroe-Norway area and perhaps also in the Biscay area, in both of which areas fin whales have been exploited into the 1960's or 1970's.

This argument rests on the assumption that the majority of the strandings of fin whales in Britain in 1913-1924 were due to natural deaths, otherwise initial rank order of the fin whale is raised. Fraser (1934) noted that some deaths were due to whaling, a few whale carcasses having been found near the Hebrides with harpoons attached. However, the distribution of stranded fin whales around Britain in 1913-1926 was not notably biased to the northwest, so I think the argument is not invalidated. Moreover, Table 3 shows there was a further lowering of fin whale abundance in strandings between median years 1942 and 1959, which parallels the post-war whaling increase at Norway and Faeroes.

I draw the conclusion that long-term observations on strandings have a value in enabling us to follow the relative abundance of species, even if the effort in reporting strandings is not quantified. Sheldrick (1976) has made some additional studies of this kind from the British sightings using 5 year time periods. I here present a reanalysis using rank order as the index of abundance, and taking into account also other north European stranding reports.

Variability in natural abundance: Delphinids in north European seas.

In European seas, Globicephala meleana is an oceanic species. Brown (1961) recorded it commonly at all weather ships west of Europe from 45°N to 59°N, being perhaps present only in summer at the more northern stations. At the southernmost of these stations, station K at 45°N 16°W, Duguy and Aloncle (1974) recorded it as the third commonest species after Delphinus delphis and Tursiops truncatus. There have been in the past fisheries for it, earlier at the Orkney and Shetland Is. (Harmer 1927) and, up to the 1970's, at the Faeroe Is. (Joensen 1962, Mitchell 1975). Joensen shows a mean catch of 1,720 animals caught at the Faeroes from 1940 to 1962, with no trend. Catching here continued at least up to 1973 with catches in the hundreds annually (Mitchell 1975).

On all coasts of the British Isles, strandings from 1913 to 1972 show G. melaena to have been the sixth commonest small cetacean stranded at 6% of recorded strandings of small species (Brown 1975). With large whales included, there would be no

change in rank order, but I do not have access to all strandings of large whales in Britain after 1966. For cumulative strandings for all North Sea and Baltic Sea coasts, Schultz (1970) shows G. melaena to be in 11th place. This analysis confirms G. melaena as an oceanic species, decreasing into the North Sea.

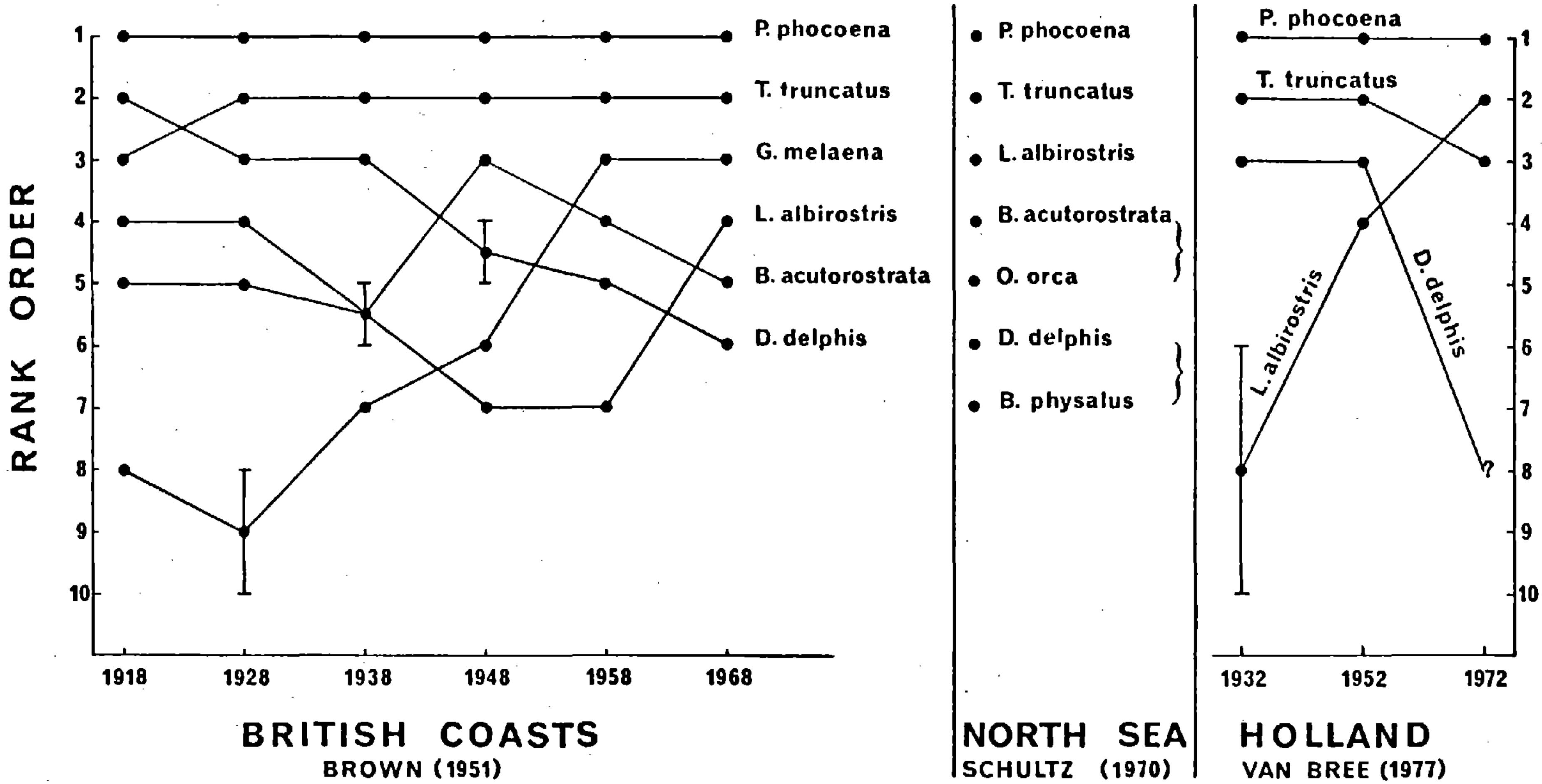
However, the pilot whale has increased its stranding frequency in British waters progressively (Sheldrick 1976). Brown's (1975) tabulations show that the increase in frequency began between about 1943 and 1948. Since percentage frequency is greatly affected by frequency of the commoner species such as Phocoena phocoena, which can be variably reported, it is better to use rank order. Figure 2 shows an analysis of this criterion. Pilot whales rose from 8th or 9th to third in rank order or commonness in British strandings in the 35 years from 1925 to 1960.

It is wise to use caution in interpreting this kind of analysis. O'Riordan (1975) cites a number of recent mass strandings and captures of schools of pilot whales at Ireland in 1840-1853, and again following 1965. There were only singleton strandings in Ireland in the interim recorded by Harmer and Fraser, five in 1913-1945, eleven from 1956-1972. While the singleton strandings would suggest that the pilot whales' increase is real, one cannot be sure from the mass strandings (and O'Riordan does not offer an opinion) whether or not the Irish reports have been very incomplete.

Other species in the British Isles and North Sea have shown

Figure 2

RANK ORDER OF SMALL CETACEA IN EUROPEAN SEAS



shifts in stranding frequency (Fig. 2). At Britain, *Delphinus delphis* began in second place, yielding by 1923 to *Tursiops truncatus* and falling steadily to 6th place by 1972. *Tursiops truncatus* has maintained itself in second place up to 1972. In the North Sea, with data for a long period summed, Schultz (1970) places *Tursiops* in second place, *Delphinus delphis* in shared 6th place. In the Celtic Sea at 45°N, 16°W and in the Gulf of Gascony, *Delphinus* ranks in first order, *Tursiops* second, in abundance at sea and *G. melaena* third, with *P. phocoena* a poor fourth (Duguy and Aloncle 1974). *Phocoena* ranks first in stranding frequency at Britain and at all North Sea localities. Yet a third change has occurred in recent years. The dolphin, *Lagenorhynchus albirostris*, has moved up from 7th place to third in stranding frequency in Britain in the last few years of reports. In the North Sea, it has long been in third place. Van Bree (1977) shows, for limited numbers of strandings, that it has recently supplanted *D. delphis* and even *T. truncatus* as the second species in Dutch waters.

Let us try to summarize the zoogeography of these changes. *G. melaena* appears as a cool-water, oceanic species. It has increased in British waters over 25 years. *D. delphis* is a warm-water, oceanic species. It has decreased concurrently. *L. albirostris*, a cool-water species rather typical of the North Sea and northward, has increased in British waters and has tended to displace *T. truncatus* in the southern North Sea (Netherlands). These changes overall would tend to suggest a cooling trend. Van Bree (1977) also has tended to relate these changes to

hydrographic changes; Sheldrick (1976), however, relates them to changes in food supply. Causal pathways appear very hard to disentangle. For instance, no data seem available on the possible change in abundance of cephalopod species which might be important to species such as G. melaena. Nevertheless, the value of the long time sequence of strandings in Britain is established; the gathering of similar statistics over the entire western seaboard of Europe would be a valuable undertaking. There are the recent beginnings of such a network in France (Duguy 1974 and earlier) and in Spain (Casinos and Vericad 1976).

Effects of disturbance and pollution.

Van Bree (1977) has noted the disappearance of Phocoena phocoena and of Tursiops truncatus from Dutch waters and believes increasing pollution to be among the factors responsible, together with heavy fishing on the food fishes and increased ship traffic with attendant noise. It is not only difficult to separate the causal factors in increasing human "nuisance" to sea mammals, but it is also difficult to chart the animals' responses. Do they die? If so, this should result in a transitory build-up of strandings followed by a decline, which does not seem to have been observed. Do they forsake the area? Or is reproduction affected? Some of the observations on Pinnipedia suggest the latter; on the Dutch coast the reproduction of Phoca vitulina has decreased (Reijnders 1976) possibly due to a loss of undisturbed calving sites (Anon 1977); in the Baltic, pesticide intake may cause anatomical changes in female seals

leading to infertility (Helle, Olsson and Jensen 1976). But <u>Phocoena phocoena</u> in the Baltic seems to have suffered most from drowning in fish nets (Mitchell 1975).

Conclusions

I have argued that the abundance of a species in strandings reflects its abundance in neighboring waters. Whether strandings are due to natural or man-induced mortality will not affect this conclusion; most strandings in the past have been due to natural mortality but man-made mortality may well increase in the future, as both whales and human activities at sea increase. I would expect that increases will occur mainly in accidents with ships and entanglements in fishing gear.

From this premise I have argued that the rank-order of a species in strandings is a measure of its abundance in local waters. Long-term records can show us relative shifts in abundance of differenct species though the probable causal mechanisms (with the exception of hunting among human activities) are usually obscure. Pollution seems likely to affect reproduction as well as mortality of small, coastal Odontocetes.

These deductions point to one recommendation: we can do with many more good coastal networks of well-reported (including accurately-measured) strandings. If these can be accompanied by a good knowledge of the Cetacean fauna in surrounding waters, so much the better. The emerging, highly enthusiastic corps of amateur naturalists can surely be trained using the best

available field guides and encouraged by museums and others to help us cover the shore line and identify Cetaceans in the near-shore seas. Maintaining a long-term effort will reap rewards once the basic faunistics of each area become known.

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LEMMING BEHAVIOR: A POSSIBLE PARALLEL TO STRANDINGS?

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Population fluctuations of rodents have been extensively investigated ever since Elton (1924) recognized these fluctuations and suggested there was some regularity to them. This vast amount of study has given rise to numerous hypotheses of population regulation in rodents (Krebs and Myers 1974). Subsequently, some of these hypotheses have been adopted as "explanations" for a variety of behavioral, physiological and population phenomena in other species of mammals. An extreme example of this, but an example relevant to this symposium, is the attempt to explain whale stranding behavior in terms of stress due to high population density (e.g., Schafer 1972) or even as a parallel of lemmings drowning themselves in the sea (Breland and Breland 1974). This paper reviews the current status of our understanding of population regulation in rodents and provides a brief critique of some basic concepts which are widely held to be correct, but for which data are limited and contradictory. In particular, the most popular hypothesis of population regulation in mammals is evaluated and found to be lacking empirical or theoretical support.

Certainly, the most intriguing phenomenon in rodent population biology is the so-called cycle of population numbers. There is no generally accepted definition of a population cycle. In this paper, cycle refers to marked population fluctuations that are repeated every three to four years in a more or less regular fashion. In rodents, these cycles only occur in the subfamily Microtinae, the voles and lemmings.

In spite of the enormous effort devoted to the study of rodent population cycles, their cause remains an enigma (Lidicker 1973). We can neither explain nor predict changes in population numbers of voles and lemmings. Failure to solve the basic mysteries of cycles has not inhibited investigators (Wilson 1975) from advocating their own special "theories," often to the exclusion of all other explanations. These "theories" are reviewed exhaustively by Krebs and Myers (1974). Here, detailed consideration will be given only to the stress hypothesis. This special consideration is shown simply because this hypothesis has attracted the most attention, not because it has superior scientific merit.

Cycles and lemmings go together, and together they have captured the imagination of both biologist and layman. Lemmings have always been surrounded by mythology and, as is often the case, the mythology has changed as our perception of the world has changed. Myths are a reflection of our views not a representation of facts, but we readily commit the

error of elevating beliefs to facts. Thus, we impose our beliefs upon a phenomenon of nature, then use the phenomenon as "evidence" to substantiate our views. In this way, the so-called lemming cycle and its associated events have been used to support some very basic and popular notions about biology and population dynamics. As usual, the only serious difficulty with these concepts is that while they are attractive to some people, they are counterfactual. The following quote serves as a classic example of this problem. "The activity of a single species (the lemming) has led scientists onto broader and broader research with conclusions of deepening significance" (Ardrey 1970, p. 178). The conclusions cited by Ardrey may have significance; unfortunately, they are also incorrect.

Lemmings may not be familiar to marine biologists, therefore, a brief introduction to these animals is provided. Lemmings have a circumpolar distribution north of the tree line and they and their close relatives, the voles, form an important part of the food webs of most terrestrial habitats in the northern hemisphere. Although signigicant in a quantitative sense, as individuals, lemmings are unprepossessing. They are small, weighing 50 to 100 g, and have short limbs, a short stubby tail and no external ear pinna. Some species turn white in winter and all are brown or gray-brown in summer. Unlike rats and mice, most species of lemmings and voles undergo large changes in population density, often in

the order of 1000-fold within a few months. The potential for rapid population growth is evident in their reproductive capabilities. Lemmings may begin breeding at 30 days of age, and have litters of up to 10 young. Females can mate again the same day they have a litter so that a new litter may be born every 20 days. Breeding can occur in both summer and winter.

There are numerous myths associated with lemmings. Some are ancient and no longer popular. For example, in both Eskimo and Scandinavian legend the sudden increases in lemming numbers occurred when thousands of these animals fell from rain clouds or with winter snowstorms. One Eskimo word for lemming translates as "creature from space." Of course, this myth of the origin of lemming population explosions was laid to rest once we understood the reproductive capacity of lemmings. In fact, another Eskimo name for lemming means "scrotal sac" which suggests, perhaps, that deep down the Inuit also knew from whence the lemming hordes came even before the concept of "r" selection was enunciated.

There are also several current myths about lemming cycles. Most of these will be dealt with briefly, as they are of secondary importance here, and actually represent specialized myths known primarily only to workers in the field. First, lemmings are supposed to migrate *en masse* for great distances. The evidence for this comes only from Norwegian lemmings (*L. lemmus*), and it is not good evidence. No animals have been marked or radiotracked and followed

over any great distance (Brooks and Banks 1973). Nor has it ever been shown that lemmings actually migrate in the true sense from point A to point B and back to A again. The evidence consists largely of unquantified observations of short movements of a few hundred metres (Curry-Lindahl 1962, Ako and Kalela 1966, Bergstrom 1968, Koponen 1970). Second, lemming cycles are supposed to be regular in their periodicity, i.e., 3 to 4 years (Krebs and Myers 1974). However, many cycles are 2, 5, 6, 10 or even 18 years (Curry-Lindahl 1962, Pitelka 1972, Lidicker 1973, Krebs and Myers 1974, Brooks unpublished data). Third, lemming cycles are supposed to be synchronized over vast areas, but most of the evidence does not support this belief. There is no evidence cycles are synchronized by some common mechanism. Finally, where two or more species of microtine are sympatric they are supposed to, but usually don't, cycle in phase. Although some (Krebs and Myers 1974) suggest that the synchrony and regular periodicity of lemming cycles are important mysteries to solve, it must first be demonstrated that these phenomena occur before we can decide how or why they occur.

By far the best known lemming myth concerns the nature of the decline phase of the population cycle. Even today the name lemming conjures up images of thousands of mindless panic-stricken rodents forging ahead to an inevitable doom, when they would hurl themselves off precipitous cliffs into the merciless cold sea. This myth has only appeared in the

last century or so, but it has remained widely popular. The lemming is still the subject of numerous editorial comments and cartoons which lampoon the foibles of man, and the suicidal marches are still used as a stock analogy when someone wishes to characterize a course of human action as foolish or reckless. Although the idea of lemming suicide has an obvious wide appeal, in fact, there is no evidence that it occurs. Present evidence suggests that cessation of breeding, dispersal, predation and other factors contribute to the decline (Myers and Krebs 1974), although considerable debate on the relative importance of these factors continues.

The key question, of course, is: how do lemmings regulate their population? Incidentally, it seems peculiar that this question has been so thoroughly pursued in a group of animals that seem singularly ineffective in regulating their numbers. Early work on this problem concentrated on the hypothesis that regulation was imposed upon the population by factors in the external environment. The most popular suggestions were disease, weather, predation and food. Thus, populations were supposed to increase until one or more of these factors stopped the increase and caused a decline. Investigations have since eliminated disease or parasites as being important. Weather and predation were also rejected, although both have experienced new support recently. Food has always remained a strong contender. Suffice to say at this point, that microtine populations have been shown to decline in situations when none of these factors could be implicated as the cause of

of the decline.

A more recent school of thought has suggested that populations regulate themselves. In other words, populations stop increasing, before they run out of basic resources, due to inherent control mechanisms. There have been two major hypotheses on how microtine populations accomplish this. The first, proposed by Chitty (1960) and later by Krebs (1964) and his associates (Krebs et al 1973) supposes that gene frequencies change during the cycle as a result of changing selection pressures. Simply put, different densities impose different selection pressures on the population. Variations in phenotypic features, particularly spacing, dispersal and aggressive behaviors are hypothesized to have a genetic basis and also to have different fitness values at a given density. Therefore, density change is a varying selective pressure which alters gene frequency (Krebs and Myers 1974). Presumably, at high density, features are selected for which cause the subsequent decline. Gene frequencies do change during the cycle, but there is little evidence to relate these changes to generation of cycles. This hypothesis merits further investigation, but so far it has had little impact outside microtine population theory.

Of the concepts of population regulation which arose from work on rodents, by far the best known is the "stress theory." It has been used to explain certain behaviors as a product of population-induced stress in a wide range of mammals including, as mentioned earlier, whales and human beings (Ardrey

1970). The stress hypothesis remains a popular idea because it synthesizes information from several areas. Work on laboratory populations of rats and mice by Christian, Calhoun and others, the supposed suicidal behavior of lemmings, the sudden unexplained declines in wild rodent populations, Selye's work on the General Adaptation Syndrome and Wynne-Edwards' espousal of group selection all seem to provide support for this idea.

Before outlining the hypothesis proposed by Wynne-Edwards (1962, 1965), we must pause to examine the group selection hypothesis. He suggested that populations evolve mechanisms to regulate their numbers and, thereby, to prevent overexploitation of their environmental resources, and that these mechanims are selected for at the population level, not at the individual or gene level. For example, dominance hierarchies and territoriality are behaviors which are selected for at the population level to regulate population density. In essence, group selection should produce individuals who sacrifice their own reproductive success for the good of the population. In the context of our recent concern over the human population "explosion," this idea is very attractive. Lemming suicides represent a perfect, though non-existent, example. Individual lemmings kill themselves and hence reduce population density to benefit the entire population (or species). Group selection is often included in the stress hypothesis, although it is not necessary for the hypothesis to be valid.

The evidence and rationale of the stress hypothesis may now be summarized. In confined populations of rats and mice, as numbers increase, endocrine disorders, cannibalism, pregnancy failure and aggression also increase (Calhoun 1962, Christian and Davis 1964, Brain 1971). The result of these changes is a decline in birth rate, an increase in mortality and "social breakdown" which cause a decline in these laboratory populations. Combined with the "evidence" from lemming suicides, Selye's work etc., these results are extrapolated to wild populations of cycling microtines, i.e., population crashes are caused by stress induced by overcrowding. Group selection explains the evolution of these responses as selection for self-regulation of the population before densities overshoot resources. Obviously, such selection benefits the group at the expense of individual fitness.

There are several problems with the stress hypothesis. First, these stress responses and physiological problems have not been substantiated in wild populations (Krebs and Myers 1974). Second, these phenomena were realized in laboratory populations in which densities were many times greater than are ever achieved in wild populations. Third, microtines in large outdoor enclosures often exceed natural peak population densities but do not show these stress responses. Fourth, there is little evidence that adrenal function (an important part of the stress response) in natural populations is correlated with density, reproduction, mortality or growth (Krebs and Myers

1974). Finally, inaccurate reports of lemming suicides, and abnormal behavior in wild lemmings (Curry-Lindahl 1963) and in overcrowded laboratory populations of rats and mice have lent support to the stress hypothesis. Aside from the fact that lemmings do not behave in abnormal ways in high density (Kalela 1962, Krebs 1964, Brooks 1970, de Koch and Rohn 1972), it is highly questionable whether the behaviors described from laboratory populations should be characterized as abnormal. For example, cannibalism and induction of abortion may seem repugnant to us, but from the point of view of a male rodent they may be acceptable strategies for improving his relative reproductive success. Thus, a male lemming may kill the progeny of other males, not for the good of the population, but simply to improve the chances of survival of his own genes.

There are also difficulties with the group selection interpretation of the stress hypothesis. The key point here is not whether birth rates are regulated, but why they are regulated (Dawkins 1976). A female lemming may cease to breed, not for the good of the population, but because if she tries to raise a litter under severe conditions probably both she and her litter will die. On the other hand, she might be able to improve her reproductive success by delaying reproduction to a more propitious time or by having smaller litters. Female aggression could, of course, serve to protect her young from competing individuals.

A simpler way to look at population regulation is to suppose that population events are the result of selection acting on

genotypes in the population. Each geneotype (individual) uses strategies to maximize its own reproductive success. Contrary to Wynne-Edwards' (1962) view this is not equivalent to maximizing fecundity. Population density is itself a selective force. Individuals must be able to respond adaptively to changing population densities or they (their genes) will be removed from the population. In this context, we can see that "suicide" or "physiological breakdown" are not adaptive responses, but failures to respond adaptively.

Perhaps we can now make some predictions. Under a group selection hypothesis, lemming suicide and physiological collapse could occur in high densities, whereas, with individual selection such behavior should not occur, or would occur very rarely. Certainly, the available data support the latter view. Understanding of animal population dynamics is unlikely to advance as long as we depend on myth, non-explanatory concepts such as "stress" and non-parsimonious hypotheses such as group selection. Future research should examine individual strategies, endeavor to test useful alternative hypotheses and, as suggested by Krebs and Myers (1974), avoid our excessive preoccupation with physiological measurements and concentrate on more relevant behavioral aspects of the individual.

To summarize, the hypothesis that stress, mediated through endocrine mechanisms, regulates natural populations of rodents has little empirical support. Selection at the group level has little empirical support and is not logically necessary

nor parsimonious (Wiens 1966, Williams 1966, Dawkins 1976). Population density itself must be viewed as a selective force. If animals are poorly adapted to high densities then they will be selected against. Hence, in natural populations, reduced birth rates should not be viewed as population regulation evolved by group selection, but rather as a manifestation of reproductive strategies of individuals which maximize individual fitness. Mass suicide or other self-destructive behavior would be truly aberrant in this view and would not be expected to occur in nature.

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THE CETACEAN STRANDING PHENOMENON: AN HYPOTHESIS

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Abstract

Live strandings of cetaceans occur every year in various parts of the world. More than half of all known species of marine odontocetes are represented in reports of strandings. Mysticete strandings are less common, and only one mass stranding of baleen whales is known.

Previous hypotheses have constituted partial explanations that are not necessarily invalid but fail to account for certain facts. These are: (a) the stranding act, whether by one or a number of animals, may be slow and deliberate or a rapid dash to shore; (b) stranded animals, whether solitary or in a group, unless accidentally trapped by a rapidly falling tide, typically refuse to accept freedom when pushed seaward but turn immediately and strand themselves again; and (c) in a number of instances stranded animals, transported to an oceanarium and introduced into a tank without medical treatment of any kind, have lived for months or years in captivity without exhibiting any symptoms of disease.

The following hypothesis represents an attempt to explain these facts.

It is commonly accepted that cetaceans are descended from terrestrial ancestors. At some time, intermediate ancestral forms must have been amphibious, and during that period it was presumably critically important for them to seek safety on land when injured, afflicted with disease, attacked by aquatic predators, or otherwise subjected to severe stress. There is evidence that organisms under stress may regress to fundamental and primitive behaviors (e.g., eating, sleeping, sexual activities). In organisms with a highly developed central nervous system, behavior under stress may be dominated by responses associated with primitive and very basic motivations and emotions regulated by subcortical systems, instead of following a more rational course under control of the cerebral cortex. The basic drives (hunger, thirst, sex, etc.) and emotions (anger, fear, pleasure) are evolutionarily conservative, i.e., resistant to change.

It is suggested that the requirement to seek safety on land early in cetacean history became a response that also was mediated by subcortical structures, that the response may manifest itself under conditions of stress, of whatever nature, and has persisted to the present time despite the fact that it long ago became maladaptive. No other hypothesis appears to account for as many of the observed behaviors and circumstances in live strandings.

Introduction

> It is not known for what reason they run themselves aground on dry land; at all events, it is said that they do so at times, and for no obvious reason.
>
> Aristotle (6)

> Every organism, whether individual or species, is the product of a long history, a history which indeed dates back more than 2000 million years... There is hardly any structure or function in an organism that can be fully understood unless it is studied against this background.
>
> Ernst Mayr (60)

Live strandings of porpoises and whales occur every year in various parts of the world. Odontocetes are much more likely to be found stranded than mysticetes, and certain species of odontocetes appear to be more prone to strand themselves than others. The number of animals in a stranding may range from one to at least two or three hundred. It is the mass strandings that receive the most attention from the popular press as well as from scientists, but solitary strandings, which often go unreported, are by no means uncommon.

In accounts of strandings, the news media generally mention one or more of the popular lay hypotheses, a favorite being that the animals are committing suicide. The whales destroy themselves, it is suggested, because they are ill, because they "are approaching the end of their alloted life span," or because "their species is overbred." Suicide connotes a level of cognition, self-awareness, and forethought for which evidence is lacking in any animal other than man. This explanation is unteneable to students of animal behavior.

An alternative idea is that the animals are trying to migrate along ancient routes and find barriers where their ancestors found open water. Other considerations aside, this does not take into account the fact that sea level is higher now than it was during the last glacial period, in relatively recent geologic time. Also, it is difficult to see how such a lethally non-adaptive trait in a particular migratory population could have persisted through hundreds or thousands of generations.

More knowledgeable hypotheses regarding the cause or causes of stranding have also been proposed. Gilmore (43) suggested that three factors operate in mass strandings: a close cohesion and organization under leaders, a sensitive nervous system which permits panic in a violent "blind" response to sudden stimuli, and non-adaptation to shallow water.

In a review of the subject, Dudok van Heel (31) listed, with annotations, all of the live strandings of which he had knowledge. He noted that strandings almost invariably occur on gently shelving shorelines and presented evidence for the ineffectiveness of the cetacean sonar system in detecting the shore under such conditions. Since coast-loving and fluviatile species are seldom known to strand themselves, he suggested that they obtain experience with shallow water and thus overcome the difficulties. Ocean species, however, would be more easily confused by faint and misleading echoes. With a herd of animals, there would be a greater number of echoes, and the sound pulses of the animals themselves might mask returning echo information. Social behavior that tends to keep the members of a herd together would add to the difficulties.

Dudok van Heel acknowledged the few reports known to him of animals that had been freed by people and pushed seaward but had turned and beached themselves again. He advised caution in assessing these reports, suggesting that if such occurrences were not attributable to the social instinct the possibility remained that the animals, once freed, were confronted with the same confusing echoes, or, as reported in one instance, were washed ashore again because they had no strength to swim.

He thought it remarkable that no mass strandings of mysticetes were known and offered the suggestion that since the baleen whales feed on schools of fish and plankton, they need only a low-frequency sonar for spotting such schools. A low-frequency sonar would give a general warning of a coast but

no detailed information, since the innate behavior of the animals would keep them well away from shore. The few coastal species are presumably adapted to shallow water, and, like the coastal odontocetes, only occasionally and by accident make the mistake of getting stranded.

In a later paper, Dudok van Heel (32) incorporated into his hypothesis the idea that odontocetes, when cruising, pay attention to the low-frequency components of their echolocation clicks in order to obtain long-distance information, but when closing on an object utilize the higher frequencies for proper identification. In hunting amid schools of fish or squid, he suggested, an odontocete concentrating on the high frequencies might easily miss weak low-frequency information from a nearby shore. He further suggested that mysticetes may be warned of the presence of a gently shelving shore of a shallow area by a low-frequency "sound barrier" created by surface waves or by their own low-frequency sounds.

Ray (85) noted that schools of pilot whales herded by Newfoundland whale drivers can be driven to strand themselves in seeming panic. Since many natural strandings involve apparently healthy animals, he suggested that stress may be a factor. Be he also thought that in the majority of cases, the animals are not in good health, either suffering from some disease or severely parasitized. Sick animals would be easy prey for sharks or killer whales and might seek the protection of shallow waters and even the support of land under their bodies.

Ridgway and Dailey (88) examined seven common dolphins, Delphinus, that had stranded individually on the southern California coast and found severe damage caused by trematodes. They suggested that this parasitism accounted for the strandings and the subsequent death of the animals. Although some investigators have not found more than what appeared to be normal parasite burdens in some stranded cetaceans (e.g., 21, 41), others have reported heavy infestations, especially in the ears and sinuses, which were believed sufficient to affect hearing and perhaps the ability to locate food and navigate (4, 29, 78, 82). Consequently, the hypothesis that parasites are at least an important factor in strandings has gained considerable currency.

None of these various explanations for strandings is mutually exclusive or necessarily invalid. At the same time, however, none of them adequately takes into account certain observed behaviors and circumstances.

In the next section, I will review accounts of strandings and findings from strandings that must be given consideration in the formulation of any comprehensive hypothesis. The references cited include notes from files, extracts from personal journals, and unpublished reports kindly provided in response to my inquiries. For such material I am indebted to Peter Best, L.C. Dunn, Paul Graycar, Edward W. Shallenberger, B.C. Townsend, Guy van Andrel, and R.M. Warneke. James G. Mead called my attention to the 1886 paper by Collett (27) which provides what is apparently the only report of a mass stranding of mysticete whales.

A REVIEW OF REPORTED FACTS AND FACTORS IN LIVE STRANDINGS OF CETACEA

Table 1 is a list, probably incomplete, of odontocetes reported to have stranded themselves. I have drawn on Dudok van Heel's list, citing his paper (31) for documentation; a number of the references he provided were either personal communications or were not available to me. In a few instances, I have included records having to do with single animals belonging to offshore species that were found dead on shore in very fresh condition; it seems unlikely that a cetacean which died some distance from land could drift ashore without obvious signs of damage or decay. Names given in some of the references have been changed to reflect currently recognized nomenclature in accordance with the synonymies provided by Rice and Scheffer (87) and the revised list of names compiled for the Marine Mammal Commission (5).

Table 2 is a similar listing of mysticete strandings. Dudok van Heel (31) mentioned five individual strandings of the pygmy right whale, _Caperea_ ("_Neobalaena_") _marginta_ on a beach near Stanley, Tasmania, but these are not included in his table, and no details are given; they may not have been live strandings.

While these tables do not represent an exhaustive survey of the literature, they do extend Dudok van Heel's list considerably and suggest that stranding may be a universal phenomenon, even though frequency of occurrence varies widely among the different species of Cetacea.

Table 1. Odontocetes reported to have stranded alive (listed alphabetically within family).

	No. of animals (range)	References
Family DELPHINIDAE		
Cephalorhynchus hectori	1	31
Delphinus sp.	1 - 15	1,31,88,95
Feresa attenuata	1 - 5	20,54
Globicephala spp.	1 - ca. 300	4,18,23,31,35 44,57,59,69,70 75,107,108
Grampus griseus	1 - 6	31,58,79,102
Lagenodelphis hosei	1	100
Lagenorhynchus albirostris	1 - 2	31
L. acutus	1 - ca. 150	31,39,41
L. obliquidens	1	110
L. obscurus	1 - 6	16,40
Lissodelphis borealis	1	75,92
L. peroni	3	38
Orcaella brevirostris	3	81
Orcinus orca	1 - 20	7,25,31,80
Peponocephala electra	1 - ca. 200	71,83
Phocoena phocoena	1 - 2	31,33
Pseudorca crassidens	1 - ca. 300	24,31,78,82
Stenella coeruleoalba	1	10,22,30,75, 76,94
S. longirostris	1 - 50	13,20,77
S. plagiodon	1 - 2	34,106

Table 1. (Continued)

	No. of animals (range)	References
Family DELPHINIDAE		
Steno bredanensis	16 - 17	57,98
Tursiops spp.	1 - 2	2,26,31,37, 57,63,72
Family MONODONTIDAE		
Monodon monoceros	1	31
Family PHYSETERIDAE		
Kogia spp.	1 - 5	11,23,47,49, 57,69,95,101
Physeter catodon	1 - 72	11,31,42,57, 103,105
Family ZIPHIIDAE		
Berardius arnouxi	1	90
Hyperoodon ampullatus	1 - 4	31,36,68
Mesoplodon bidens	1 - 2	31,55
M. bowdoini	1	73
M. densirostris	1	64
M. europaeus	2 - 3	69,84
M. ginkgodens	1	74
M. grayi	25	31
M. hectori	1	90
M. layardii	3	31
M. mirus	2	95
M. stejnegeri	1	91
Ziphius cavirostris	1	8,66,67,69, 75

Table 2. Mysticetes reported to have stranded alive.

	No. of animals (range)	Reference
Family BALAENIDAE		
Eubalaena glacialis	1	86
Family BALAENOPTERIDAE		
Balaenoptera acutorostrata	1	31,75,80
B. borealis	1 - 13*	27,50,51
B. edeni	1	11,86,94
B. musculus	1	31
B. physalus	1	19,23,31,48 61,69
Megaptera novaeangliae	1	23,31,62

*See text

Comments on Species Known to Strand

At least 38 species of marine odontocetes have been known to come ashore. To my knowledge there have been no reports of members of the freshwater family Platanistidae stranding themselves. Strandings of coastal and estuarine species seem to be very uncommon. Dudok van Heel (31) listed four strandings of Phocoena phocoena, each involving two animals (in one instance, at least, a mother and calf), and a solitary stranding occured in Connecticut in 1976 (33).

Of the few Tursiops live strandings known to me, two involved captive animals kept in fenced enclosures (2, 26). A Tursiops stranded alive on the Irish coast with a full-grown spotted dogfish "firmly wedged head-first in its oesophagus" (72); one stranded on a North Carolina beach and refused to swim away when pushed off (63); and two animals, a 280-cm female and 302-cm male, stranded together at, appropriatly, Strand-on the-Green in Middlesex, England, "many miles" from the mouth of the Thames (37).

There appears to be only one stranding record for the narwhal (31) and one for the Irrawaddy dolphin, Orcaella, in which three animals reportedly stranded together on the shore of one of the inland seas of Thailand (81).

Globicephala spp. are usually considered to be pelagic species and seem to be more subject to mass strandings than any other cetaceans. Yet there seems to be only one recorded mass stranding along the California coast (75), where G. macrorhynchus regularly comes inshore to feed on squid. Similarly, while G. melaena is common along the east coast of Canada, Sergeant and Fisher (96) reported only seven mass strandings on that coastline from 1930 to 1954; in those waters, too, pilot whales comes inshore to feed on squid. This suggests that pilot whales that are accustomed to coming close inshore to feed on squid adapt to shallow waters and, in accordance with the explanations suggested by Gilmore (4) and Dudok van Heel (31) are less prone to strand themselves.

Table 2 represents a total of only 23 strandings, and some of these may have been accidental entrapments caused by a rapidly falling tide.

In what seems to be the only report of a mass stranding of a mysticete species, Collette (27) wrote: "During a stay in Finmark in 1878, I received information that a shoal of 13 whales, of about 40 feet in length, had stranded in a bay of the Porsangerfjord to the east of the North Cape. I did not have an opportunity of visiting the place; but as the baleen-plates of these whales were described as being black, it seems very probably that they belonged to this species (Balaenoptera borealis)." If indeed 13 mysticete whales, whatever their

identity, stranded in the fjord, it would be of interest to know whether this might have been an accidental entrapment. In response to my inquiry, Dr. Age Jonsgard of the University of Oslo informed me that there are flats in the fjord, some of which might be considered extensive. However, the tidal data Dr. Jonsgard provided indicated that the maximum tide is only 235 cm, suggesting that the accidental stranding of 40-foot whales would be unlikely.

The paucity of reports concerning mysticete strandings may, in part at least, reflect their relative numbers, but it seems probably, nevertheless, that baleen whales are less prone to strand than odontocetes.

Nature of Stranding Sites

Dudok van Heel (31) attached great importance to the fact that most strandings occur on gently shelving sandy beaches where the cetacean sonar systems could not, according to his experiments and calculations, function adequately. While it is true that most strandings seem to occur on shelving sandy beaches, the exceptions are worth noting. In Dudok van Heel's list of 133 strandings, eight occurred on beaches described as rocky and five others have the notation "rocky shoreline" or "rocky coast." In addition, I have found a number of other instances of strandings on rocks or rocky beaches (1, 8, 11, 20, 24, 25, 55, 84, 95).

In one unique "stranding," two male spotted dolphins, _Stenella plagiodon_, a pelagic species, were found alive in a man-made saltwater lake on Marathon, one of the Florida Keys. The only access from the Gulf of Mexico was by two culverts, each 91 cm in diameter and 12 m long. The approach from the Gulf was a small cove, rocky and shallow (34). This event was all the more remarkable because, as trainers at oceanariums know, delphinids generally exhibit great reluctance to pass through constricted openings and must be patiently trained to do so.

Behavior of Stranded Animals When Freed

It is now well known that stranded odontocetes, when moved off the beach and pushed or towed seaward, typically turn immediately and strand themselves again. This has been recorded for at least ten genera - _Delphinus delphis_ (1, 88), _Feresa attennuata_ (20), _Globicephala_ (23, 57), _Kogia_ (57), _Lissoldelphis borealis_ (92), _Pseudorca crassidens_ (24), _Stenella coeruleoalba_ (10, 30, 76), _Steno bredanensis_ (98), _Tursiops truncatus_ (26, 63), _Ziphius cavirostris_ (8, 66) - in solitary or mass strandings. Occasionally, however, attempts to free stranded animals have been successful. The circumstances have varied.

According to Morzer Bruyns (70), 36 of 40 pilot whales which stranded at Hawkes Bay, New Zealand, were successfully refloated. All seemed to be "semi-conscious." Rolling, shaking, and beating reportedly revived them, and they swam back to open sea.

Three southern right whale dolphins, <u>Lissodelphis perroni</u>, found stranded on a beach at Onekaka, New Zealand, were returned to the sea "and swam away apparently none the worse for their temporary sojourn on land" (38).

When at least 17 rough-toothed dolphins, <u>Steno bredanensis</u>, came in over a reef at Kihei, Maui, Hawaii, on 27 June 1976, many were taken offshore and released, some more than once. Of those taken several miles out, at least one returned, but apparently the others swam away (98).

On 13 March 1961 at Newport, Rhode Island, a 5.8 m <u>Ziphius</u> was found aground, upright with head pointed seaward. It was towed offshore several times by an amphibious vehicle, but each time returned, sometimes coming to rest on a rock. Even when released facing seaward, it returned to shore. Eventually, the whale, which was gaunt and clearly in poor health, was killed (8).

According to a newspaper account, a 4 m <u>Ziphius</u> which stranded on Malibu Beach, California, was hauled to deeper water by a boat and did not return (66).

On a few occasions, freeing stranded animals has apparently suceeded through persistence. In a stranding of 12 pilot whales near Ponte Verdra, Florida, on 23 May 1958, a group of men and boys attempted repeatedly to free one 3 m animal that appeared to be in good condition. After an hour, one husky teenage boy still persisted, keeping the animal afloat and turning it seaward every time a wave swung it toward the beach. After another 20 minutes, the whale moved slowly out to sea

and disappeared (107). Alpers (1) told of seven Delphinus delphis that stranded on a rocky beach in New Zealand. Attempts to push them off met with no success, and the following day all but two were dead. Children of the families staying nearby renewed their efforts. Eventually "little outings became longer and more confident, until finally the pair of dolphins simply swam away toward the open sea."

In a series of strandings by or from the same herd of pilot whales on the west coast of Florida between 19 and 25 August 1971, attempts to push the animals to deeper water from a beach on Gasparilla Island, where they had come into the shallows, were futile until the two largest males were towed by boats about 400 m out and held by tail ropes. The others then reportedly left the beach and moved slowly offshore. Oddly, the same two large males had initially remained about 50 m offshore while the others moved into shallow water. Later in the day, a collector from a marine exhibit at St. Petersburg Beach located the herd about 2 km offshore. Using a device that puts a loop of rope around the tail stock he captured a 2.75 m animal and began towing it to shore. The others grouped tightly around and followed. When the boat was close to shore, it was stopped so that the captured whale could be untied for transfer to a waiting van. The whale herd, however, continued slowly and deliberately toward the beach in tight pod, the two large males coming along near the rear of the group. Again, after futile attempts to push the animals into deeper water, the two large males were towed offshore. The behavior of those

remaining noticeably changed. After being pushed seaward, each whale seemed less apt to return though some did. Eventually, all left the beach, joined the large males, and moved slowly through a pass to open water. Five days later, however, 12 or 13 pilot whales, including one of the large males (identified by an abnormal dorsal fin and rope burns on its tail stock) came ashore in the Marguesas Island, 35 km west of Key West, Florida. Six, including the large male, reportedly were successfully pushed back to sea, but the remainder died (35). Whether the survivors stranded again is not known.

A similar series of strandings by a herd of false killer whales, _Pseudorca crassidens_, also occurred on the west coast of Florida. On 25 July, 1976, 30 animals, ranging from a calf to a large 5.4 m male, came into the shallows at Loggerhead Key, Dry Tortugas. It was believed that four _Pseudorca_ that had stranded at Charlotte Harbor, Punta Gorda, Florida, 140 nautical miles away, three days earlier (with a fifth stranding and dying on Captiva Island on the way in) had come from this herd. At Loggerhead Key, the large male was flanked by 14 or 15 of its fellows which maintained a wedge-shaped formation, noses pointed toward the beach. The tide was negligible, and the animals could move about but strongly resisted being separated from the herd. When the large male died after three days, the formation around him loosened. The remaining animals (some had apparently departed the preceding night) permitted themselves to be pushed into deeper water and swam away in a northeasterly direction (78, 82). What was presumed to be the same herd was found

dead and decomposed at Cape Sable, Everglades National Park, on about 15 August (78).

From these and other accounts, it is clear that stranded animals that are "successfully" returned to open water may strand again at a different location, but it cannot be said that this is always the case.

The behavior of freed animals differs and may offer a clue as to whether they are ill or otherwise in a state of prolonged stress, or instead have beached themselves as a result of some transitory stimulus or have accidentally become stranded. A minke whale that stranded in Cook Inlet in Alaska in June 1971, where the tides may be as high as 12 m, was believed to be the victim of a rapidly ebbing tide. Kept wet, and freed on the next tide, it swam away (3). On 11 September 1968, in False Bay, Cape Province, South Africa, a 9 m Bryde's whale was found on a beach some distance below the high-water mark and pointing seaward. It was kept moist until the tide came in and then, with human assistance, was refloated. The whale immediately headed very rapidly out to sea (11).

In two reported mass strandings, the nature of the sites, the presence of large amounts of food, and the departure of some of the animals on a following high tide, all suggested accidental strandings. On 6 September 1974, a large herd of Atlantic white-sided dolphins, Lagenorhynchus acutus, stranded on mud flats at Lingley Cove, Edmunds, Maine, which had a 5 m tide at the time. After one tidal cycle, 48 animals were

found dead, but from depressions in the mud it was estimated that approximately 150 had been stranded. Immense amounts of herring had been reported in the bay during the preceding five days (41). On 3 November 1967, about 50 pilot whales stranded near Morsalines, France, on extensive flats which reportedly had a fast-running tide. Most of the whales put back to sea on the following high tide. Vast quantities of cuttlefish were reported to be in the vicinty at the time of this stranding (18).

The stomachs of stranded animals, when they have been examined, have usually, but not always (e.g., 80, 98), been reported as empty. This has been taken to mean either that they were ill and inappetent or unable to locate and catch food because of parasitic infestation that affected their sonar capability. It seems likely, however, that empty stomachs are not necessarily significant. Dr. Sam H. Ridgway informs me that examination of stomachs of captive porpoises that had died and were posted not long after they had taken food has revealed that the stomachs were empty (except perhaps for fish bones) within an hour or two after the time the animals had eaten.

The Stranding Act Observed

In a number of instances, cetaceans have been observed in the act of stranding. Sometimes they have dashed straight on onto the beach, and sometimes their movements have been slow, and the stranding has appeared to be very deliberate.

On 19 November 1935, 200-300 _Pseudorca crassidens_ stranded near Mamre, South Africa (45, not seen). L. Green, quoted by Dudok van Heel (31), wrote of this stranding, "they came in suddenly through the breakers, leaping over the rocks, a farmer told me. It was determined dash, and those that survived the battering threw themselves on and on until they reached the sand...They made tremendous efforts to jump over all obstacles..."

On 4 December 1970, a female _Delphinus_ was first seen swimming three-quarters of a mile up Bushman's Creek, Eastern Cape, South Africa. Before she could be guided into the channel from a side pool, she "charged the sandback" and was dead by the time observers reached her. She was said to appear quite normal internally (95).

On 18 April 1957, two whales, later identified as _Mesoplodon bidens_, were seen in a shallow creek on the southwest side of Gossen Island in Romsdal, Norway. They were swimming side by side with bellies touching bottom. Their movements appeared more and more irresolute. Finally they turned shoreward, still side by side. The larger animal drove straight onto the sandy beach and labored a great deal in its death struggle. The smaller whale moved southward along the shore, then turned toward land and drove onto a crag about 20 m from where the larger had stranded. (55, not seen; quoted in 31).

On 5 March 1971, a 228 cm male _Mesoplodon mirus_ calf stranded on a shelving sandy beach at Plattenberg Bay, South Africa. It was pushed back into the water by tourists who had observed it strand. As it swam seaward, an adult female, presumed to be the calf's mother, shot past it onto the beach. The calf then followed. Macroscopic examination of the female revealed no parasites in nasal passages, lung, liver, heart, kidneys, blubber, or air sinuses. The calf had milk in its stomach, so it had apparently been nursing normally shortly before it stranded (95).

One stranding that is significant in several respects was by a female _Lagenorhynchus obliquidens_ named Pat who had been in captivity for more than four years and had been worked untethered in the open sea for six months in preparation for expected participation in the U.S. Navy's Sealab III program. On 25 March 1969, Pat's trainer, John Hall, took her out for boat-following exercise, moving east off Point Mugu, California. Two gray whales were sighted, and when Hall approached to within 185 meters of them, Pat left the boat at high speed to a spot near where the whales had sounded. Hall then turned the boat to the west and Pat rejoined it. After progressing about half-a-mile, Hall stopped the boat, rubbed the animal, and had it perform a few simple trained acts. They continued west another half mile and again stopped, with Pat being rubbed and fed. Shortly after the boat started again, Pat suddenly and for no apparent reason bolted at very high speed toward a small promontory. She ignored the acoustic recall signal and could

not be headed off. When about 200 yards offshore she made a slight turn to the east, then again headed, more slowly now, straight for the beach and entered the surf. When next seen, she was floundering in a wave that had broken over her. Hall radioed the marine mammal facility for help, and beached the boat near Pat. A truck arrived in a few minutes, and Pat was returned to the facility. She appeared uninjured except for superficial scrapes. After being placed in a tank, she appeared very lethargic for the rest of the day. She would not come to the side of the tank when summoned and ate only two fish. On the following day her appetite and trained responses had returned. In three days, she appeared completely normal and a few weeks later, Hall had her back working at sea (from an unpublished manuscript by John Hall; also in references 88 and 110). Pat gave no further indication of aberrant behavior, although in May 1970 while working in the ocean with Hall, she suddenly left the boat and headed seaward, perhaps to join a herd of her own kind that had been sighted earlier.

On 28 April 1962, a whale later identified as Mesoplodon stejnegeri, was first seen swimming into San Simeon Bay, California, heading almost due north. It swam directly into the shallow surf at the north end of the bay and floundered there for nearly two hours before expiring. It appeared to be "trying to get through the point" of land which encloses the north and west portions of the Bay. When examined the following day, blood was oozing from pores over the head region, and

the animal was presumed to have been injured, possibly by exploding dynamite charges set off by an oil company about 25 miles to the south a day or two previously (91).

On 12 December 1971, a 15.8 m sperm whale appeared offshore from Swartvlei Beach, Cape Province, South Africa, and swam toward the rocks. Just before reaching the rocks it reportedly turned and faced seaward, then turned again and "quite deliberately" swam onto the rocks. It died later the same day (11).

On 18 June 1973 in later afternoon, campers at Punta Bufeo, Baja California, observed five dolphins, later identified as *Grampus griseus*, swimming near shore apparently feeding on mullet. At about 1730 hours, they stopped chasing fish and moved directly toward shore. One began moving up the gradually sloping beach into no more than a foot of water and began "rooting in the sand" with its snout. This continued for about ten minutes. The animal's breathing was labored, and it seemed unable to maintain an upright position. The other four remained with it, nudging it and appearing at times to try to force it into deeper water. They were not frightened away even when touched by people entering the water. The breathing of these four sounded fuller and their actions appeared to be more coordinated. By 1800 hours, the first animal was stranded. The other four moved off the beach but stayed nearby. By midnight, the first animal had died and was being borne up the beach by the rising tide. At dawn, this

animal, a female, was high and dry, and the other four had stranded themselves about 85 meters down the beach. They were alive at 0600 but died by 0800. All were estimated to be about 3.5 m long. Three were females; the sex of the fourth was not determined. None gave any evidence of recent injury (58).

Strandlings of wild Tursiops appear to be very unusual, as discussed earlier. The following accounts concerning captive animals are therefore of interest.

On 15 July 1971, the Miami (Florida) Herald announced the "Mitzi, Original 'Flipper' of Movies, Is Dead." According to the story, Mitzi died after struggling through the night to beach herself on the coral rocks surrounding her shoreline corral at Grassy Key, Florida. Her owner said that the 15-year old porpoise's efforts to beach herself "reflected the animal's instinctive fear of drowning...She had behaved dejectedly for at least two days before her death (and had) refused to eat or perform."

On 6 April 1975, a female Tursiops truncatus that had been kept for nine months in a fenced off lagoon in Kaneohe Bay, Oahu, Hawaii, was found partially stranded on a shallow rocky area of one end of the enclosure. She had shown no signs of disease or ill health. Attempts to return the animal to deeper water met with strong resistance. When removed from the water for examination she appeared to be in shock. Despite treatment she died about 30 hours later. The most significant necropsy finding was an abscess 1.5 cm in diameter beneath the cortex of the right cerebral hemisphere (26).

Parasites or Disease as a Factor in Strandings

Based on an examination of seven Delphinus found stranded near Pt. Magu, California, between 1966 and 1970, Ridgway and Dailey (88) concluded that stranding and subsequent death of the animals could probably be attributed to severe damage by trematode parasites, including ova found in the brain. Heavy parasitic infestation, especially of the inner ears and nasal passages, was found in eight carcasses recovered from a stranding of about 100 Lagenorhynchus acutus at Orleans and Wellfleet, Mass. It was speculated that the parasites had impaired the animals' sonar so that they could not find their way back to sea as the tide receded (39). Pilot whales from a series of strandings along the South Carolina coast were found to have helminths in the middle ears and pterygoid sinuses, with infestations ranging from tens of worms to upwards of a thousand on each side of the head. It was postulated that the level of parasitism in most of the whales interfered with their ability to hear and hence to echolocate, so that they were unable to feed and navigate (4). In the previously described series of strandings of false killer whales at Charlotte Harbor, Florida, and Loggerhead Key, Dry Tortugas, examination of five animals revealed large numbers of nematodes in the ear sinuses of all of them, and it was suggested that this may have accounted for the stranding (78, 82). Walker (104), discussing mortalities in small odontocetes captured off the California coast for exhibition purposes, reported that the incidence of naturally occuring

parasitism in 22 Delphinus was minimal, and that in the pilot whales examined lungworms and trematode infections were not observed. For Pacific coast animals, at least, Walker's findings appear to support the hypothesis that parasites play a significant role in strandings.

It may be noted, however, that in some strandings there was no evidence that parasites or other pathological conditions were implicated. In the South African stranding of a female Mesoplodon mirus, which seemed to be triggered by the initial stranding of her calf, macroscopic examination revealed a few nematodes in her stomach but no parasites in nasal passage, lungs, liver, heart, kidneys, blubber, or air sinuses (95).

Odell (77) examined the ears of Stenella longirostris from a stranding at Casey Key, Florida, on 13 July 1976, finding some trematodes and a few nematodes. The brains were examined by N. R. Hall who, according to Odell, found no pathology. It was concluded that the animals were probably normal.

In the stranding of Pat, the Lagenorhynchus obliguidens, the animal appeared to be in good health both prior to and following her stranding (110); there was no evidence that physical impairment from paraistes or other pathology played any role.

In the stranding of at least 17 Steno bredanensis on Maui on June 1976, nine animals died and were posted. They have severe abrasions, presumably from the reef over which they had come, but only one had what appeared to be a severe pathologic

condition in the form of constricted arteries. All were "remarkably free of parasites," and several showed evidence of having eaten not long before the stranding (98).

There are too few data from which to draw firm conclusions, but the available evidence indicates that while parasite infestations or other pathologic conditions may be an important factor in strandings, they do not account for all strandings. The fact that some stranded animals have survived in captivity without receiving medical treatment, as described in the next section, corroborates this.

Behavior and Survival of Stranded Cetacenas in Captivity

The first pilot whale (Globicephala macrorhynchus) to be kept in captivity was from a herd of 46 that came ashore at St. Augustine Beach, Florida, on 6 October 1948. Two females and two smaller males from this stranding were transported to the Florida Marineland and immediately placed in a circular oceanarium 23 m in diameter and 3.5 m deep which was occupied by a number of Trusiops truncatus. The two females died first. The larger of the two males survived eight days, and Henry Kritzler, then curator of Marineland and author of the account (56) from which this information has been taken, felt "certain" that it would have survived if suitable food had been available. The animals had shown no interest in fish. On the ninth day, a small quantity of squid was obtained. The surviving male rejected the squid during daylight hours but took them eagerly after dark. This animal died on 9 July 1949 after being rammed

with great force by a Tursiops during a feeding about a week before. It was found to have suffered a break in the left ramus of the lower jaw. It had appeared to be in good health throughout its nine months in captivity.

On 16 December 1959, nine G. macrorhynchus from a herd of 57 that came ashore along a mile of beach just south of Flagler Beach, Florida, were brought to Marineland and placed in a fenced-off inlet connected to the Intracoastal Waterway. The animals ranged in length from 2 to 4 m. For two or three hours after they were placed in the inlet, men had to be stationed around the bank to prevent them from grouding themselves. They finally grouped together and swam slowly around the middle of the inlet, their backs exposed. Only during the latter part of the period that they survived did some submerge during attempts to feed them. So far as could be determined, none voluntarily took fish or squid at any time. Despite the administration of antibiotics and a gastric demulcent, along with the forced feeding of two animals with ground squid, all died, the last one 20 days after the stranding (108). Although gross autopsies were performed, the records have apparently been lost. Perhaps the most significant feature of this account, however, is that the whales attempted to come ashore on all sides of the inlet for two or three hours after being placed there.

On 13 June 1973, nine pilot whales, identified (probably incorrectly) as G. melaena, beached themselves on Grassy Key near Marathon, Florida. (A tenth, over 6 m long, was discovered

a quarter-mile away two days later, still alive but badly cut by rocks; it died after being towed to a nearby yacht basin.) One of the nine, a 2.6 m female, was still alive in 1 m of water when the stranding was discovered. Although towed to sea several times, she persisted in swimming back to shore. She was then moved to a boat basin, and six days later to the Flipper Sea School at Marathon where antibiotics were administered, lanolin applied to her seriously sunburned back, and a liquid died of 4-5 g of l.c. minced shrimp and fish force-fed daily. The whale was reported to be playing and swimming actively until the day prior to her death on 30 July, 45 days after the stranding, although she would not accept the stomach tube for three days prior to her death. She was found in the shallowest part of the pool, suggesting that she may have attempted to beach herself there. Preliminary autopsy results indicated a severe case of pneumonia (59).

On 4 May 1966, four Grampus griseus from a stranding of six (two were found dead) at Crescent Beach, Florida, were taken to Marineland and placed in the oceanarium tank occupied by bottlenose dolphins. No medical treatment was administered. Two days later, three of the four took squid thrown on the water, and on the third day ate from the hand; the fourth took thrown squid on the third day and could be hand fed on the fourth. Two of the animals died 7 and 9 weeks, respectively, after being brought in, one apparently of a large lung abscess. The remaining two lived 2 years 8 months and 3 years 7 months, respectively (102).

On 2 September 1958, a 2.2 m Kogia was found, apparently very recently stranded, on a beach adjacent to the Florida Marineland. Although much of its body was exposed, the skin was not dry, and the animal appeared to be in excellent condition. It was quickly carried to Marineland and placed in a receiving tank 12 m long, 6 m deep. The whale reacted violently, thrashing about in the corners of the tank and driving its head well out of the water as if (it was my impression) trying to get out of the water. A gate leading to the circular oceanarium was opened and the struggling animal was maneuvered into the oceanarium tank. It immediately swam at high speed, counterclockwise, around the perimeter, hitting the right side of its head against the porthole indentations and incurring severe damage to its right eye. After a number of circuits it slowed down and thereafter cruised slowly around the center of the tank or drifted with the current.

The whale was given broad-spectrum anitbiotics intramuscularly and was semi-force-fed thread herring, one man catching and holding the animal, another pulling its jaw down and pushing a fish as far as possible into its mouth. Surprisingly, it refused squid as well as octopus,although later its forestomach was found to contain a number of squid beaks. On the 23rd day after being brought in, the whale accepted 21 herring almost voluntarily, but the next day it firmly resisted taking food, and on the day following it died. On necropsy it appeared grossly normal, but the ears and brain were not examined (57, 109).

On the morning of 17 April 1975, a 1.8 m male Kogia was found stranded at Flagler Beach, on the east coast of Florida. It was brought to Marineland of Florida where antibiotics and a vermifuge were administered before it was placed in a tank 9 m in diameter and 3 m deep. A few nematodes were later found in the tank. In the afternoon of the same day, the whale accepted hand-held fish and squid. During the almost three months that it lived in captivity it ate somewhat erratically but did not refuse food for any extended period. On one occasion the animal leaped out of its tank, sustaining superficial cuts and lacerations. It was quickly returned to the water, and it accepted food a few hours later. The whale was reported to be robust at the time of its death, which occurred when it rammed the wall of its tank shortly after it had been fed on 12 July 1975. On necropsy it was found to be grossly normal; no parasites were detected in its ears. The brain was preserved but apparently has not been examined (46).

Phocoena phocoena has had the reputation of being difficult to keep in captivity. It is typically parasitized with lungworms and subject to "capture shock" (31). The survival in captivity for almost two years of a stranded Phocoena is therefore noteworthy. On 18 March 1976, a 27 kg, 148 cm female was found stranded on a gently shelving shoreline of the Niantic River in Connecticut. The porpoise's back was dry with sloughing skin. A fast-acting steriod and antibiotic were administered before the animal was moved to the Mystic Marinelife Aquarium

where additional medical treatment was given. The porpoise swam with a list to the left side for the first 24 hours. Its breathing was erratic and it "coughed" frequently. On the second day in captivity it accepted five hand-held squid, but for the next week had to be force fed. It then ate some live killifish, and thereafter took dead fish. The porpoise had no significant medical problems until a few weeks before its death on 27 February 1978. On autopsy it was found to have esophageal ulcers, acute bacterial bronchopneumonia and trematodiasis (33, 99).

One of 17 or more Steno bredanensis stranded on the island of Oahu in 1976 was reported to Sea Life Park. The dolphin accepted fish a few hours after being placed in a tank. It was thin (unlike the other animals in the stranding) and had a high white-cell count. Antibiotics were administered, and the animal in time appeared completely recovered. As of April 1978, it was alive and in good health (98).

The behavior of stranded odontocetes that were brought into captivity has varied widely and allows for little more than speculative interpretation. While one young Kogia adapted readily, taking food from the hand within a few hours, another reacted violently when placed in a tank, and gave the impression of trying to get out of the water. It is perhaps significant that only a short time elapsed between the stranding and the introduction of this animal into a tank. Whatever impelled it to beach itself may have influenced its initial behavior in

captivity. The severe damage to the right side of its head from impact with the porthole indentations must have had an adverse effect, but once past its initial violent behavior, the animal exhibited no evidence of disorientation or any inability to avoid the wall of the oceanarium tank.

From the foregoing material, certain significant facts and inferences can be drawn:

a. The majority of odontocetes known to strand themselves is generally considered to be pelagic, or oceanic. Coastal forms strand alive only rarely.

b. Although most strandings apparently occur on gently shelving shores, a significant number has been reported at rocky beaches or on rocky coasts. In one instance the animals came in over a reef, lacerating themselves in the process.

c. Stranding odontocetes do not encounter land by happenstance. When pushed off the beach or even when towed some distance seaward, they almost invariably return directly to shore.

d. In some instances, however, presistent attempts to free stranded animals have succeeded, at least temporarily. The action of repeatedly pushing an animal away from the beach is not too dissimilar from the rolling, shaking, and beating to which certain apparently "semiconscious" pilot whales were subjected before they "recovered" and swam away.

e. Mass-stranded animals that were induced to swim away have in some instances stranded again at a different site.

f. There is evidence that animals which may have been accidentally stranded by a rapidly falling tide while feeding over extensive flats have (at least if physically able) accepted freedom on the next high tide.

g. The act of stranding has in some instances been slow and seemingly deliberate, in others a rapid dash to shore.

h. Although in some strandings the animals have been found to be heavily parasitized or otherwise seriously ill, in others no indication of an excessive parasite burden or other pathological condition has been apparent. The stranding of the Lagenorhynchus, Pat, very clearly belongs in the latter category. Moreover, some stranded animals that were brought into captivity and given no medical treatment of any kind, have survived for periods of months or years in apparent good health. The fact that two stranded animals (a Kogia at the Florida Marineland and the Steno at Sea Life Park) accepted food within a few hours of the time they were placed in a tank also appears significant.

Any attempt to explain the stranding phenomenon must take into account all these observations.

AN HYPOTHESIS FOR THE STRANDING PHENOMENON

Ray (85) suggested that stress may be a factor in panic-induced mass strandings, while illness is probably the cause of most solitary strandings. In the present paper stress is considered in a broader sense; I define it here as an emotionally disruptive influence stemming from fright, injury, illness, or some other non-normal circumstance.

The hypothesis I will present had its origin in discussions with the late Keller Breland almost 20 years ago. My contribution derived from observations of a number of strandings along the upper east coast of Florida. Breland, an animal bevahiorist with a background in psychology, suggested a possible explanation for strandings based on experiences and insights gained in working with more than 60 species of animals. The hypothesis was briefly mentioned in Animal Behavior, by Keller and Marina Breland (15), but it appears to have remained unnoticed, ignored, or rejected. In any event, it can be properly assessed only on the basis of much more comprehensive and detailed documentation.

Early History of the Cetacea

Paleontological evidence indicates that the mammals arose near the end of the Triassic period from land-living therapsid reptiles, and so were themselves terrestrial (93). It follows then, that the early ancestors of the cetaceans lived on land, but later, in the course of the long transitional period leading to a completely aquatic existence, must have been amphibious.

During most of this period they must have come ashore to bear their young (as pinnipeds do), and it is reasonable to suppose that their behavior in other ways reflected their terrestrial origin. When injured, ill, or attacked (or even frightened) by aquatic predators, land would represent a place of refuge and safety.

Present day pinnipeds are in the same situation. Along the lower California coast, for example, sick or injured seals and sea lions are often found hauled out on beaches which these animals do not normally frequent.

Even the amphibious iguana, Amblyrhynchus, of the Galapagos Islands has been reported to exhibit the same land-seeking response when stressed. Darwin (28) wrote: "I several times caught this same lizard, by driving it down to a point, and though possessed of such perfect powers of diving and swimming, nothing could induce it to enter the water; and as often as I threw it in, it returned...Perhaps this singular bit of apparent stupidity may be accounted for by the circumstance that this reptile has no enemy whatever on shore, whereas at sea it must often fall a prey to the numerous sharks. Hence, probably, urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge."

I suggest that in the amphibious ancestors of the Cetacea the need to seek safety on land may have become ingrained in subcortical structures as a stress-induced "drive." It is known

that very primitive and fundamental motivations and emotions are regulated by subcortical systems (12). Such basic drives as hunger, thirst, and sex, the behavioral state called sleep, and emotions like fear, anger, and pleasure must surely be evolutionarily very conservative, although they have, especially in man, come under controls and constraints imposed by the cerebral cortex.

Some Effects of Stress on Behavior

In the course of conditioning a large variety of animals, Breland and Breland (14, 15) encountered behaviors for which conditioning theory offered no suitable explanation. A raccoon, conditioned to pick up a coin and put it into a container, exhibited reluctance to let go of the coin but would finally turn it loose and receive his food reinforcement. When required to pick up two coins, however, he not only could not let go of them but spent seconds and even minutes rubbing them together and dipping them into the container. The rubbing behavior became worse as time went on, in spite of non-reinforcement.

A pig was conditioned to pick up large wooden coins, carry them several feet, and deposit them in a "piggy bank." At first, the pig worked eagerly picking up a coin, carrying it to the bank, depositing it, and running back for another. Thereafter, over a period of weeks, the behavior became slower and slower. The animal might run eagerly to get a coin, but on the way to the bank would repeatedly drop it, root it, toss it in the air, pick it up, root it some more, and so on. This problem behavior developed in pig after pig.

In these and other examples cited by the Brelands (14), there was a reversion to behavior associated with food geting or eating. Stated in more general terms, the animals appeared to be trapped by strong instinctive behaviors probably induced by stress. The Brelands termed the phenomenon "instinctive drift."

Some so-called "displacement activities" appear to be of a similar nature are are frequently observed in zoo animals. Meyer-Holsapfel (65) told of a male lion that had to stay in an open enclosure shortly before feeding time while its cave mates were admitted to the inner cages. Immediately, the lion would lie down in the middle enclosure and go to sleep.

Hypersexuality is frequently seen in zoo animals (52, 65). Again this may be explainable in terms of "instinctive drift" under the stress of captivity.

All of these behaviors represent basic drives that are regulated by subcortical systems. Differences in the response to stress are presumably attributable to the circumstances (the behavior required of the pigs and raccoons, for example, was tied to a food reward) or individual predispositions (as may have been the case with the lion).

Fleeing from a threat, or apparent threat, is a very common and surely very ancient instinctive response. It occurs in all vertebrates, from fish to mammal. Yet flight is often disadvantageous, since it usually incites pursuit or even calls to the attention of a predator potential prey of which it had not been aware. In a number of animals quite different strategies have evolved, including aggressive bluff,

"freezing," and "playing possum."

Human behavior patterns are moderated by the cerebral cortex, yet humans can panic, and their impulse often is to flee blindly from the panic-inducing stimulus;yet flight may not be a rational and appropriate response to the situation. Generally speaking, in stressful circumstances, we do not think clearly and logically, and our behavior tends to reflect an emotional rather than rational state.

In alien and unfamiliar surroundings animals (including human beings) generally exhibit signs of stress. Irvine (53) described the behavior of Atlantic bottlenose dolphins and Pacific white-sided dolphins when introduced into pens in a California lagoon after being maintained in concrete tanks on land. The animals appeared lethargic, were unresponsive to training for 6 to 48 hours, and often refused to eat. Twice animals escaped from their lagoon pens prior to their release into the lagoon for open-water training, and one animal, a white-sided dolphin, twice wandered away from its trainer during the initial stages of open water training. In every instance the animals were found in shallows near shore swimming in aimless patterns. Listless and unresponsive when found, they rapidly reverted to normal behavior when returned to their now familiar pens. While movement into shallow water might not otherwise seem remarkable for Tursiops, the pelagic white-sided dolphin also ended up in the shallows after traversing water three to six meters deep. These and other observations (see,

for example, chapter 9 of reference 110) indicate that odontocetes are quite susceptible to stress. As in other captive animals, stress brought about a temporary loss of conditioned behavior, and it is reasonable to assume that naturally conditioned behavior, including "normal" cerebrally-mediated behavior in feral animals, is similarly affected.

Discussion

Disregarding possible accidental entrapment by a rapidly falling tide, most of the observed behaviors and circumstances associated with strandings appear to be explainable on the basis of stress, if it is accepted that under stress the animals may revert to responses regulated by subcortical systems - responses which at one time in cetacean phylogenenic history had adaptive value.

The paucity of live-stranding records for coastal species may be accounted for, as suggested by Gilmore (43) and Dudok van Heel (31), by their familiarity with a shallow water environment. Perhaps for this reason, the ancient urge to find safety on land or in the shallows has been moderated, that is, they may be better able to retain control of their behavior when under stress. It seems possible, too, that by the nature of their environment coastal animals have been subjected to more varied experiences than their pelagic cousins. The more varied the experiences of animals, including people and porpoises, the less stressed they are by a new experience or situation. Nevertheless, live strandings of inshore forms have been reported.

Although pilot whales, which are very prominent stranders, are usually considered to be pelagic animals, there are indications that populations that come into inshore waters to feed are less prone to strand themselves.

There is little question that the majority of strandings occurs on gently shelving shores. The hypothesis (31) that the animals become confused and disoriented because their sonar is ineffective in the shallow water near shore is not supported by observations of the behavior of animals in the act of stranding or by the fact that stranded animals, even when towed well offshore, almost invariably return to land. Nor does it explain why members of pelagic species enter the shallows in the first place. While strandings on rocky shores are by no means unknown, and in at least one instance a stranding herd of dolphins came in over the shallows of a reef, it may be that such coastal features provide a much stronger echo-return; this could result in cortically controlled behavior overriding the "emotional" urge to go ashore. It can be speculated that, depending on the source and degree of stress, the animals might then either recover (from, for example, the transitory stress of panic) of, if in a state of prolonged stress, later go ashore at a different location where strong echo-return is lacking.

The apparently successful, though in some cases only temporary, return of stranded animals to the sea following persistent efforts of rescuers or, as in one report, rolling, shaking, and beating, might have occurred because such treatment served

to restore cortical control of behavior, just as shaking or a slap on the face may bring a person out of the state of emotional shock.

There appears to be no question that severe parasitism or other illness is the stress factor responsible for many strandings. Even when direct evidence is lacking it seems reasonable to speculate that in most cases the slow and apparently deliberate stranders are ill. Repeated strandings by members of the same herd could also be interpreted as attributable to the prolonged stress of illness, though not necessarily illness shared by all members of the herd; social cohesiveness may also play a role.

The explanation that the animals simply come to land because they are ill is inadequate, however, not to say anthropomorphic. Members of most pelagic cetacean species can have had no experience with shallows and the shore, and it is hardly credible that they "intentionally" travel what must often be considerable distances (a point discussed further on) to enter a situation which is outside the range of their experience.

Moreover, not all strandings can be ascribed to illness. Aside from negative autopsy findings, which cannot be considered conclusive, several kinds of evidence suggest that stranding may occur as the response to some transitory panic-inducing stimulus. This cause of stranding would appropriately explain the rapid dashes to shore described in some accounts, and especially seems to apply to the stranding of the captive *Lagenorhynchus*, Pat. The report concerning the three

Lissodelphis in New Zealand which, when returned to the water, swam away suggests that the stress that brought them to shore was temporary. (The account contains no indication that this might have been an accidental stranding.) Additional evidence is provided by those stranded animals that have survived in apparent good health for months or years in captivity with no medical treatment.

I have not explicated what may constitute a "transitory panic-inducing stimulus." It could be an attack, or even the sudden and unexpected threat of attack, by large aquatic predators like sharks or killer whales.

It can reasonably be inferred that stranders that have survived in captivity with no sign of illness were probably victims of panic and it is also reasonable to suppose that the panic would be of relatively brief duration. This raises the question as to how far such animals may travel to reach shore. For that matter, the question also applies to animals that come ashore under the stress of illness or injury.

As previously noted, the majority of stranders are members of species which normally are found well offshore, or at least in deep waters. *Kogia* spp., to take only one example here, are usually considered to be pelagic, although Gaskin (40) cites evidence that one specimen taken in Holland had been feeding on small crabs, and another found stranded in a New Zealand bay had been feeding on the locally common arrow squid. The possible proximity of the shores to deep water might help

account for these apparently unusual occurrences. Assuming that *Kogia* is typically an animal of deep water, it is of interest to note that a number of *Kogia* strandings (including some not documented in this paper) have occurred in the vicinty of Marineland on the east coast of Florida. According to Hydrographic Chart No. 1111, published by the National Oceanic and Atmospheric Administration, the 100 fathom line lies about 44 nautical miles offshore from this section of coast. The water depth does not exceed 12 or 13 fathoms within 17.5 nautical miles of shore. At Padre Island, Texas, where a number of *Kogia* strandings have occurred, the 20-fathom line is about 14 nautical miles offshore. If the *Kogia* that stranded at these locations started from deep water, it is apparent that they must have traveled a considerable distance to reach land. But how, if they are miles at sea, do the animals know in what direction the nearest land lies? Perhaps in some instances they are able to detect the sound of a heavy surf. Heavy surf is not always present, however, and in at least one stranding of a *Kogia* at Marineland (109) the sea was quite calm.

For these and other questions (such as: what happens if the stranding impulse takes over in mid ocean and why have members of pelagic species stranded up rivers?) even speculative answers are hardly warranted with present knowledge.

Concluding Remarks

The hypothesis that has been presented here is that cetaceans still retain, from their amphibious ancestors, a subcortically-induced incentive to seek safety on shore when severely stressed - a "blind" (but not directionless) emotional response. Probably the principal objection to the hypothesis is that this behavior has for millions of years been maladaptive. Animals that come aground are usually left high and dry by the tide and are either dead or in no condition to swim away on the next high water, even if they did not strand becasue of the stress of illness in the first place.

Part of the answer may be that the land-seeking urge is, according to the hypothesis, associated with other basic and primitive emotions and motivations which, despite the considerable control of behavior that has come with development of the cerebral cortex, are evolutionarily resistant to change. It is also possible that the stranding response is genetically linked to another subcortical function that has higher adaptive value. Further, this behavior may not have had a significant effect on cetacean mortality. Illness may well account for the majority of strandings; animals that strand as a result of illness are very likely going to die anyway. Hence, in this respect at least, there may be relatively little selection pressure acting to alter the genetic code.

There still remain puzzling aspects of the stranding phenomenon. Nevertheless, the hypothesis set forth here appears to account for more of the reported facts and circumstances of

cetacean strandings than any other. Unfortunately, the hypothesis is not readily susceptible to experimental confirmation or refutation, nor does it seem likely that future observations could bring about any significant revision of this explanation for strandings.

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INFORMATION GAINED FROM STUDIES ON STRANDED ANIMALS

STRANDINGS: A RARE LOOK INTO THE BIOLOGY

OF THE ATLANTIC WHITE-SIDED DOLPHIN, _LAGENORHYNCHUS ACUTUS_

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INTRODUCTION

The distribution of the Atlantic white-sided dolphin, _Lagenorhynchus acutus_, on both sides of the North Atlantic is well documented. Reports from Mercer (1973), Schevill (1956), Sergeant and Fisher (1957), Sergeant et al. (1970), Waters and Rivard (1962), and several unpublished records and communications indicate that those along the western North Atlantic tend to inhabit "slope" water of 9° to 15° C between the Gulf Stream and the cold inshore water originating from the Labrador Current, entering the warmed surface layer of this water only in summer.

Most of the information on this species has been obtained

[1]We are indebted to S.A. Testaverde, New England Aquarium, for statistical analysis of morphometric data

from natural or provoked strandings, many of which have involved from nine to twelve animals, but groups of 200 to 250 are said to have been driven ashore in the Newfoundland whale fishery in the past (Sergeant and Fisher 1957). The material from these strandings and from captured specimens has provided useful, though limited, information on the biology of this species. Fraser (1934, 1946, 1953), Gresson (1968), Guldberg and Nansen (1894), Jonsgaard and Nordli (1952), Sergeant and Fisher (1957), and Sergeant et al. (1970) have given detailed measurements and descriptions, which have helped to devise a rather loose length-weight relationship, a single age estimation and some other data pertinent to life-table construction. Schevill (1956) provided additional descriptive information from a captured specimen and commented on the behavior of a small group of live dolphins which he encountered off the Cape Cod shore. His brief remarks reflect what little is actually known of the biology of these animals.

Through an intensive six-year stranding recovery program, utilizing single and mass-stranded dolphins, we have gained new insights on growth, reproduction, maturation and herd composition in _L. acutus_. Rigourous statistical treatments have not yet been applied to all the data, but this preliminary analysis illustrates how data collected from stranded animals can be transformed into a meaningful life history picture.

DATA AND SAMPLE COLLECTION

All data were collected from dolphins stranded along the New England coast from southern Massachusetts to Maine. The sample consists of three subgroups as follows: a herd of 13 dolphins (and 9 associated fetuses) stranded at Wellfleet, Massachusetts in May 1973; 59 dolphins (and 10 associated fetuses) selected from a herd of approximately 150 stranded at Lingley Cove, Edmunds, Maine in September 1974; and a composite sample of 22 singly stranded dolphins collected over a 3 year period, 1974-77.

Morphometric data were taken in accordance with standard procedures (Norris 1961). Teeth were collected from all dolphins for aging by counting tooth layers (Sergeant 1959); age data are presently available from only the Lingley mass stranding.

Stomach contents were collected for identification. Bony material was preserved in a solution of equal parts alcohol and glycerin, and fleshy material was fixed in either alcohol or formalin for examination. J. Fitch (Calif. Fish and Game), M. Mercer (Fisheries and Marine Service, Canada), and J. Kingsbury (Cornell Univ., N.Y.) identified items from the stomach contents.

Gonads were weighed and preserved in formalin for use in assessment of reproductive condition. Ovaries were sectioned and grossly examined for corpora (by D. Sergeant, Fisheries and Marine Service, Canada). Histological

preparations of testes and epididymis were scrutinized for the presence of sperm.

RESULTS AND DISCUSSION

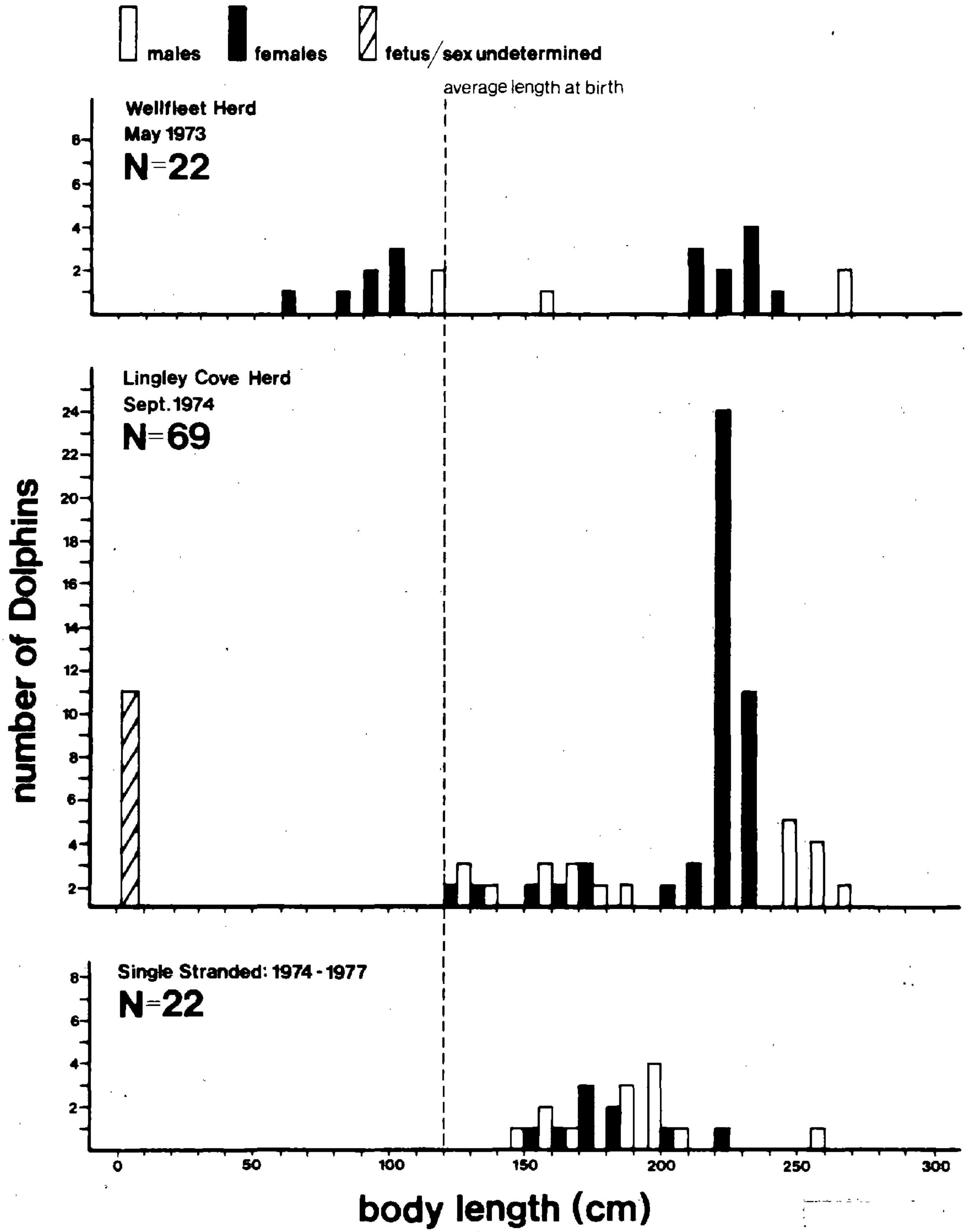
Length and sex composition

Biases in length (age) and sex composition are apparent in each of the three groups of dolphins (Fig. 1). The ratio of females to males in the Wellfleet and Lingley Cove herds was four or five to one, with only 4 dolphins in the range of 180 - 210 cm. Conversely the female-male ratio among the singly stranded dolphins was 9:13, reflecting either social-segregation of sub-adult dolphins or higher mortality rates for males, or both. This pattern of herd composition is not uncommon among cetaceans, particularly in sexually dimorphic species. A herd of pilot whales, Globicephala macrorhynchus, stranded in St. George Inlet, Florida in February, 1977, consisted of 47 males and 88 females (1:1.9 ratio); the ratio for mature animals was 1 male : 5 females (SEAN, 1977). We observed similar but less pronounced segregation in two mass-stranded herds of long-finned pilot whales, G. melaena (Geraci and St. Aubin 1977).

Growth

Fetuses taken at Lingley Cove in September ranged in length from 1.8 to 7.0 cm ($\bar{X}$ = 4.5 cm); those from Wellfleet in May were nearly full term, and ranged from 83.5 to 113.7 cm ($\bar{X}$ = 103 cm). The length-weight relationship W = 0.02684

Fig. 1 Length and sex distribution of L. acutus from the mass strandings at Wellfleet and Lingley Cove, and single strandings along the New England coast.



$\times L^{2.814}$ (weight in kg, length in cm) was derived from the combined mass stranding data as well as from published reports. There is a gap in data from fetuses of 12 - 84 cm. Figure 2 shows fetal growth rate and estimated birth size based on fetal lengths taken in May from Wellfleet, in September from Lingley Cove, and from literature reports. These data strongly point to a gestation period of approximately 11 - 12 months, with breeding occurring in July and August, and calving in June and July. The reported neonatal size range for *L. acutus* in the eastern North Atlantic in 108 - 122 cm (Fraser 1934 and 1953, Utrecht 1959). Using our data in conjunction with this range, it appears that calving can occur as early as mid-May and extend into August. This represents the widest limits of the range; mean calving time might occur in late June.

Body length in relation to tooth layers is shown in Fig. 3. Length - weight relationships, calculated from the mass stranded dolphins, were as follows:

males (n = 14) - $W = 2.32 \times 10^{-5} \times L^{2.892}$ (r = 0.996)
females (n = 37) - $W = 2.12 \times 10^{-5} \times L^{2.920}$ (r = 0.990)
combined (including 2 unsexed dolphins, n = 53)
- $W = 1.59 \times 10^{-5} \times L^{2.970}$ (r = 0.993)

An accurate growth curve for juvenile animals cannot be described at this time due to the lack of tooth layer data from 180 - 210 cm. dolphins. Nevertheless, it is possible to estimate growth rate during the first 2.5 years, based on the month of stranding, and data on body length, tooth layers and

Fig. 2 Growth rate of L. acutus fetuses collected from mass strandings from Wellfleet in May (N=8) and Lingley Cove in September (N=9), and from published reports. The reported neonatal size, in association with these data, supports a calving season from mid-May to August. Reference lines are visually fitted.

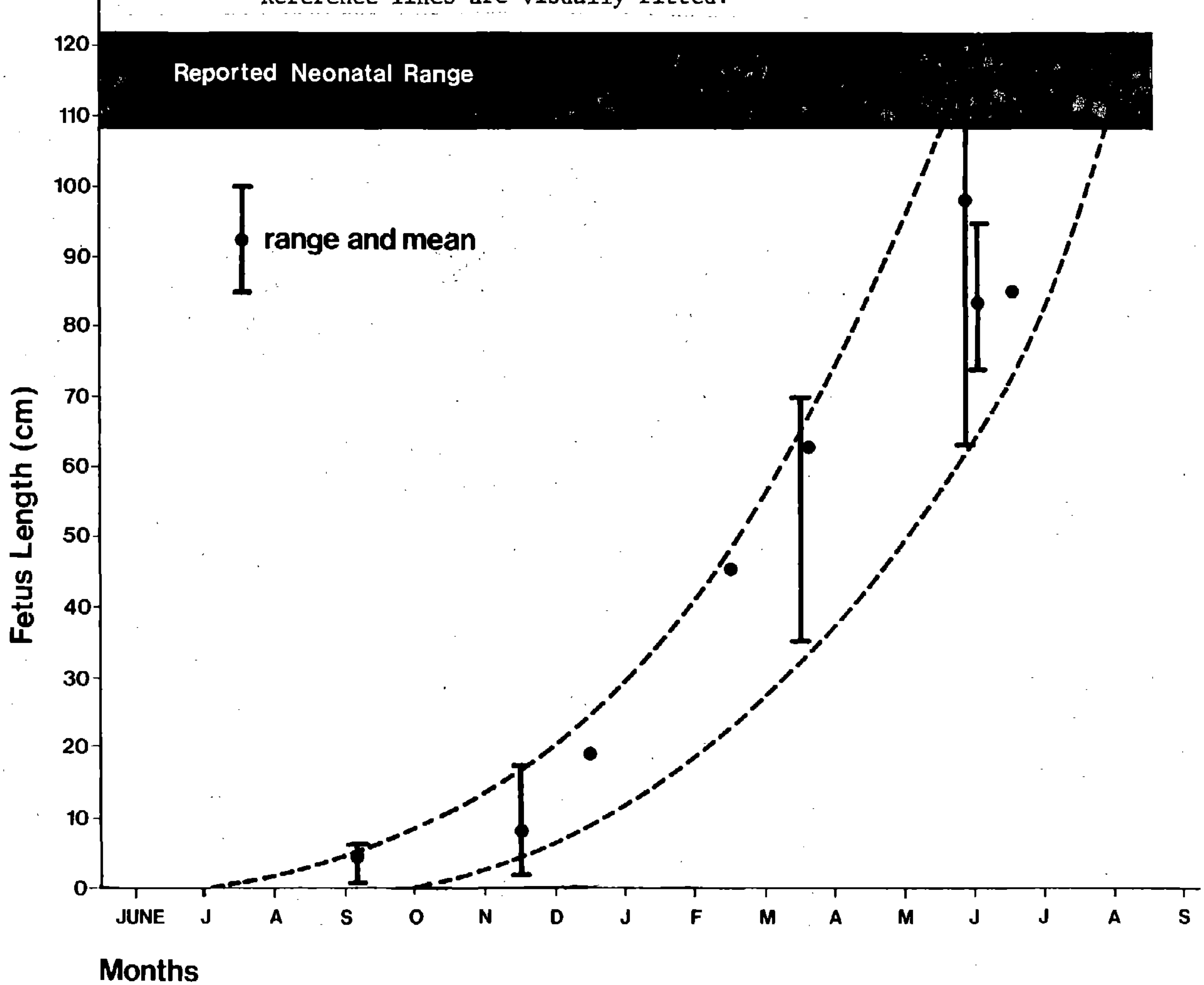
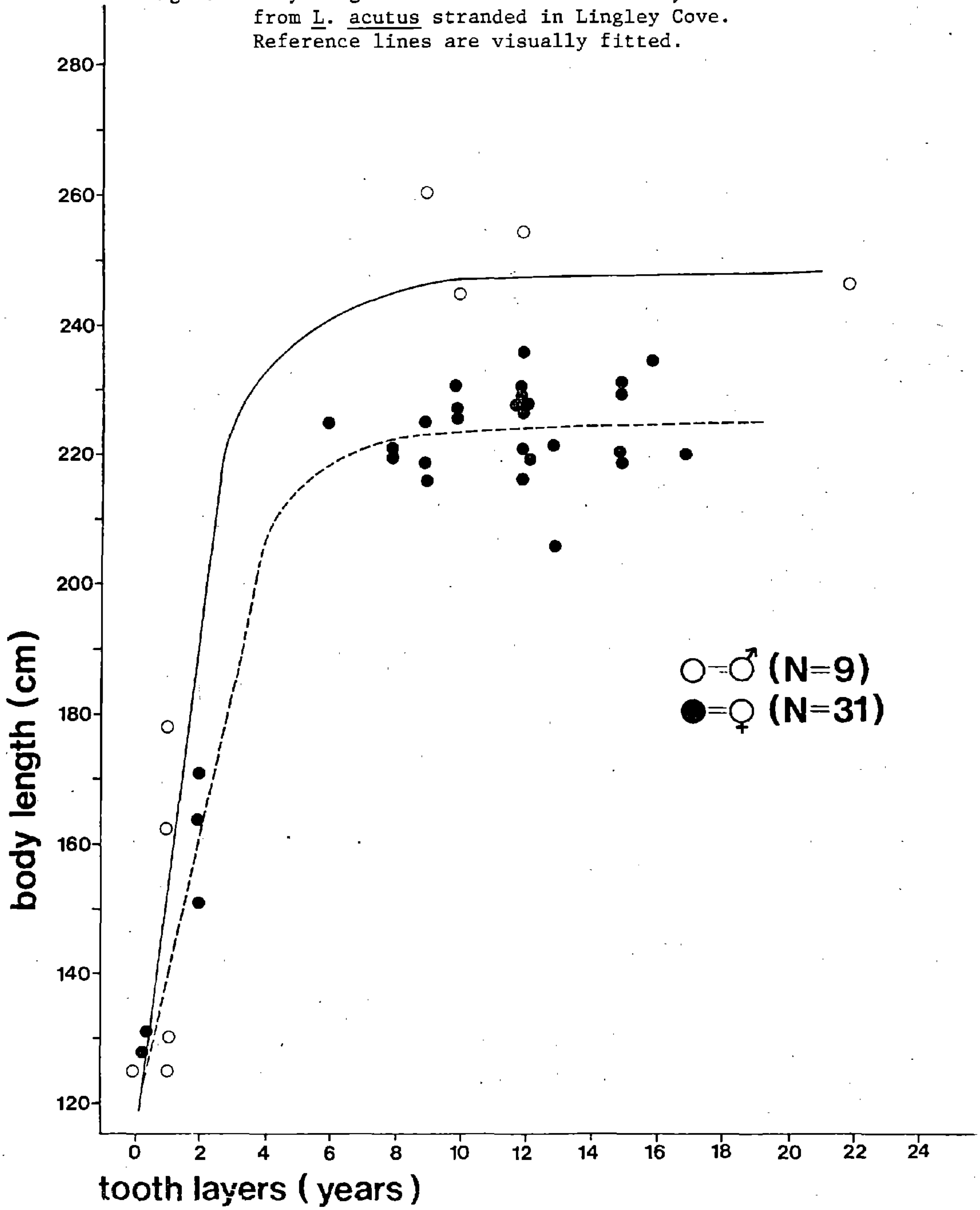


Fig. 3 Body length in relation to tooth layers from L. acutus stranded in Lingley Cove. Reference lines are visually fitted.



tooth eruption (Fig. 4). Calves in the 0^+ and 1^+ age classes are easily distinguishable, while size distinctions between older age (180 cm +) groups become progressively less apparent. A mean annual growth rate of 29 cm was calculated.

Evidence from the Lingley herd places the age of physical maturity at close to 8 tooth layers. Early growth is rapid between 0 and 3 years of age (Figs. 3 and 4), with the earliest signs of maturation evident in a pregnant female with 5^+ tooth layers. There are definite indications of physical maturity, confirmed by vertebral epiphyseal closure, in most animals with more than 8 tooth layers. The rate of growth appears to be more rapid in males, and continues after females have reached physical maturity (Fig. 3). Males are larger than females at equivalent ages, and there is pronounced sexual dimorphism at maturity.

Sexual maturity - males

Four males from the Lingley Cove herd, aged 8 to 22 years with body lengths of 244 - 361 cm, were judged to be sexually mature. Sperm were found in the epididymis of three examined. The sperm measurements were as follows: total length, 28.4 - 33.3 µm; head length, 3.9 - 5.9 µm; tail and neck lengths, 23.5 - 29.4 µm.

Males up to 202 cm long had individual testis weights which were less than 9 g. A 233 cm dolphin had a mean testis weight of over 40 g, while the four mature dolphins had an average testis weight of over 282 g. Seasonal fluctuations

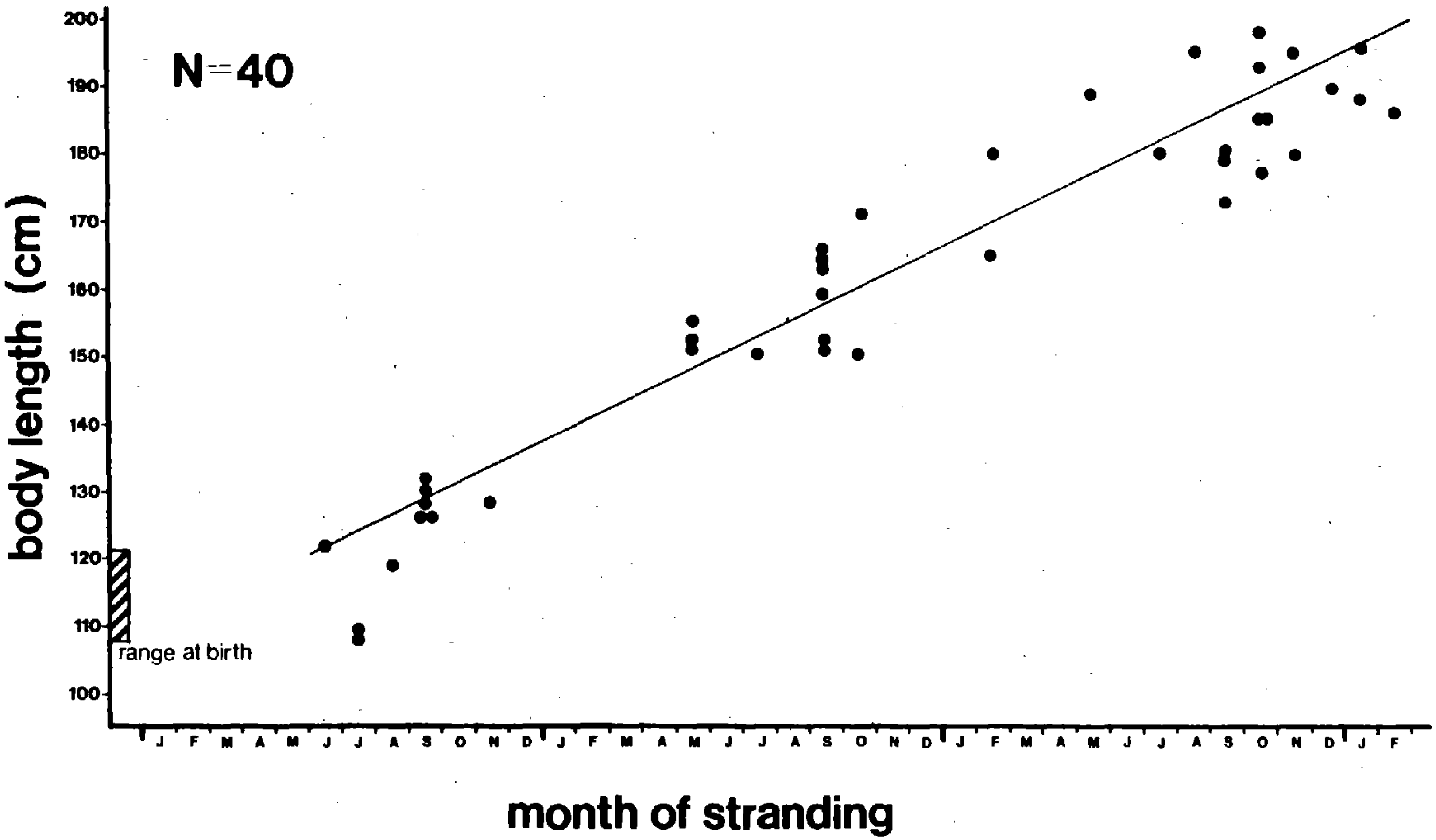


Fig. 4 Growth curve of L. acutus during the first 2½ years, based on the month of stranding. An annual growth rate of 29 cm. was calculated from the regression line.

in testis weight have not yet been determined. The mature males in the Lingley herd were sampled at a reproductively active time of year, and the data do not account for cyclic changes in testis weight, if present.

The precise age of sexual maturity cannot be determined due to the lack of data from animals in the critical length categories. However, a rapid increase in testis weight, which presumably coincides with puberty, occurs in dolphins 230 - 240 cm long, or approximately 4 to 6 tooth layers.

Sexual maturity - females

Thirty-one of thirty-four females with body lengths greater than 205 cm were either pregnant or lactating, or both. Corpora lutea and/or albicantia were noted in their ovaries, and total ovary weight ranged from 6.9 to 25.0 g. Thirteen dolphins from 128 to 185 cm were considered immature; combined ovary weights were 0.7 - 4.6 g. The youngest pregnant, and therefore sexually mature, dolphin had 5^+ tooth layers. This female had a total of 8 corpora (2 lutea and 6 albicantia), which is an indication of the unreliability of the corpora as an indicator of reproductive history.

A proposed reproductive cycle of L. acutus can be constructed from the estimated gestation and lactation periods. The fetal growth curve suggests a gestation period of approximately 11 months (Fig. 2). The duration of lactation can be estimated from the ratio of lactating-to-pregnant

females and the gestation period (Sergeant 1973). In the Lingley Cove sample, 16 dolphins were lactating and 10 were pregnant; the calculated lactation period is approximately 17 - 18 months (11 months x $\frac{16}{10}$). This estimate is supported in part by stomach content findings in dolphin with 1^+ tooth layers. This is the youngest age at which these dolphins have been observed with solid food, and is presumably associated with weaning.

Four dolphins in the Lingley Cove herd were both pregnant and lactating, indicating that it may be possible for females to give birth every second year (Fig. 5). Females, with 1 year old calves, that do not mate in July and August presumably go through a period of reproductive inactivity following the weaning of the previous year's calves. The length of the reproductive cycle for these dolphins is 3 years.

Feeding behavior

Fourteen of the forty stomachs examined from the Lingley Cove dolphins contained identifiable food items. Most prevalent were beaks and pens from the short-finned squid, _Illex illecebrosus._ Fish remains included otoliths, vertebrae and other bones, and crystalline lenses; no half digested food was found in any of the stomachs. Fish otoliths were identified from smelt, _Osmarus mordax_, and silver hake, _Merluccius bilinearis_.

The crustacean components, while insufficient to permit

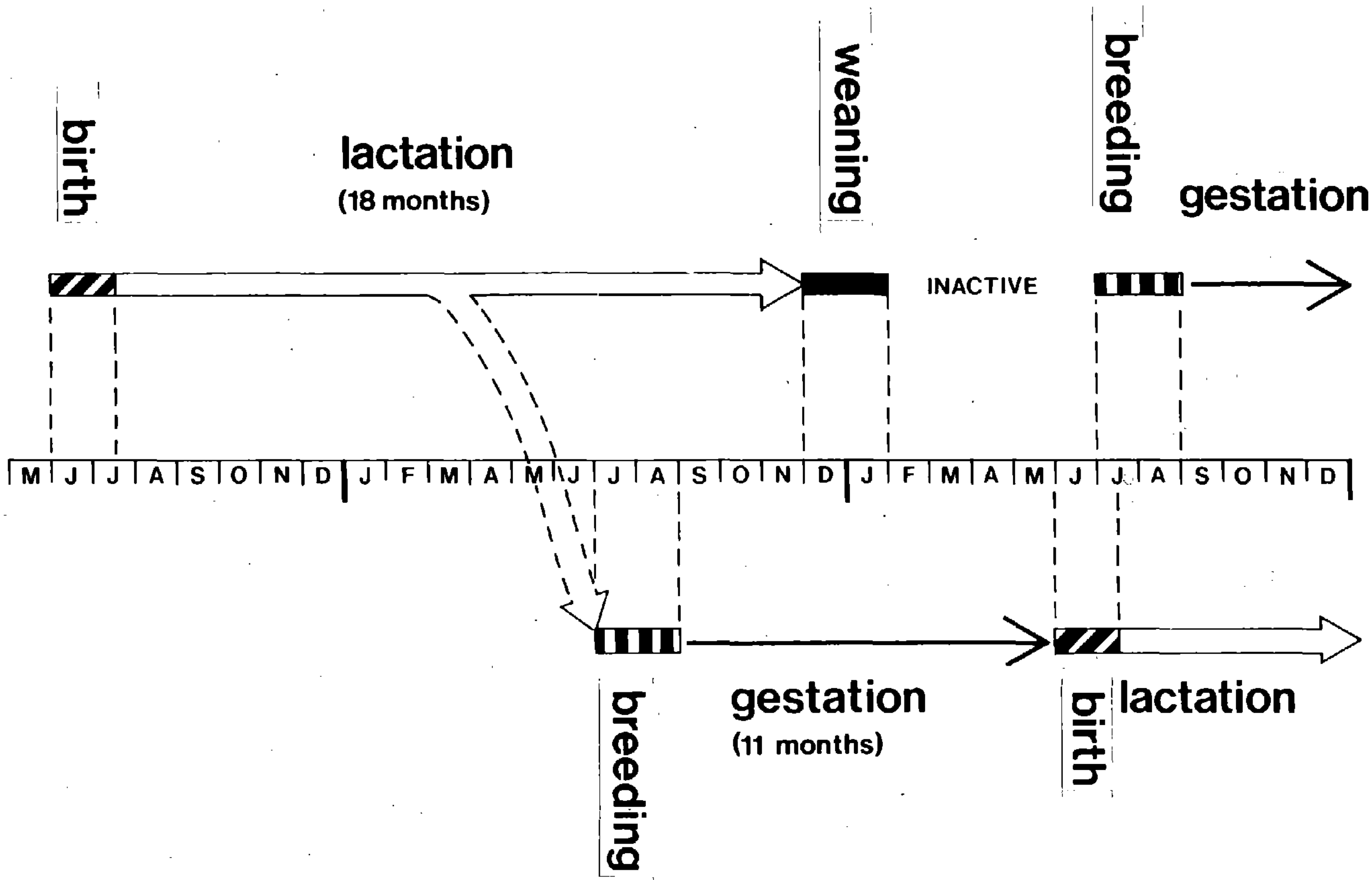


Fig. 5 Proposed reproductive cycle of female *L. acutus*. Dolphins which breed prior to weaning the previous calf (dotted arrow) reproduce on a two year cycle.

positive identification, were suggestive of Spirontocaris sp. (Family: Hippolytidae) or Meterythrops sp. (Family: Mysidae). Both species of shrimp inhabit the deeper northern waters as far south as Cape Cod. Twenty-six of the stomachs contained no food, though 4 animals had watery fluid, and mud was found in 8 stomachs. These were likely ingested during the mass stranding. Also noted was a small clam, Gemma gemma, and and many broken and tidal-worn shell fragments in the stomachs.

The relative paucity of stomach contents in the mass stranded herd from Lingley Cove serves to diffuse the notion of inshore feeding as a factor contributing to the stranding. The animals might have vomited or digested the food during the time they were mired in the mud flats. Yet neither vomiting nor vomitus was observed, and the stress of stranding would likely dull or eliminate the parasympathetic influence on digestion. Despite the large proportion of empty stomachs, the food items which were collected give some indication of feeding habits and are also useful in determining the age of weaning.

Distribution and Seasonal Movements

Stranding location and time of year provide valuable information on migration patterns and herd distribution. The recovery of a specimen of L. acutus from Long Island, N.Y. (Testaverde and Mead, unpublished) represents a southerly extension of known range along the Eastern seaboard of nearly

200 km. Evidence for geographic as well as social segregation of juvenile dolphins, particularly young males, is suggested by the seasonal stranding pattern. Young nursing calves are recovered only during the summer or early fall months, when the herds enter the warmer inshore water. Only weaned calves with body lengths greater than 170 cm are found stranded during the winter months; presumably they continue to occupy inshore waters after the breeding herds retreat offshore. This feature of their life history has implications in feeding behavior and exposure to potential human and environmental impacts (i.e. oil spills).

As more data are gathered, the gaps represented by missing age classes will be filled enabling a more precise estimate of such features as the ages of sexual and physical maturity. Nevertheless, the present data gathered from strandings are sufficient to allow a detailed account of the life history of L. acutus, bringing this species from relative obscurity to one of the better understood offshore odontocete species.

Acknowledgments

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A SUMMARY OF INFORMATION DERIVED FROM THE RECURRENT MASS STRANDING OF A HERD OF FALSE KILLER WHALES, *PSEUDORCA CRASSIDENS* (CETACEA: DELPHINIDAE)

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Abstract

A herd of at least 29 false killer whales (*Pseudorca crassidens*) entered shallow water on the southwest coast of Florida (U.S.A.) on 22 July 1976. One died, 4 were taken into captivity after stranding and later died, and 24 returned to sea. On July 25 a herd of 30 *Pseudorca* stranded on Loggerhead Key, Dry Tortugas, about 325 km south of the first site. At least some of the animals from the two strandings were identical based on dorsal fin photographs. One of the Loggerhead Key animals died and the rest were forced back to sea. Three were found dead near Cape Sable, Everglades National Park, on 2 August. Twenty skeletons were recovered in the same area on 28 August. Cape Sable is about 190 km ENE of the Dry Tortugas. These animals were probably the same animals that were forced off Loggerhead Key. Body measurements, organ weights and reproductive data were collected from 6 animals that were necropsied.

Blood data from 34 animals indicate stress but were, in general, comparable to normal values for other small cetaceans. The cause(s) of the strandings were not determined.

Introduction

The false killer whale is one of several species of odontocetes known primarily through its relatively frequent mass strandings. However, because investigators have been unable to take advantage of many strandings very little data are available on the natural history of *Pseudorca* (Mitchell 1975a, b). *Pseudorca* is distributed world wide in temperature and tropical waters (Mitchell 1975b), and has stranded in large numbers (Norman and Fraser 1948, Dudok van Heel, 1962, exceeding 800 in one case, Tomlin 1957). The first record of *Pseudorca* from North America came from Biscayne Bay, Florida, in 1918 (Miller 1920). Caldwell *et al*. 1970 summarized the Florida strandings (also see Bullis and Moore 1956, for other American records). The purpose of this paper is to describe a series of false killer whale mass strandings that occurred in Florida during the summer of 1976.

Sequence of events

1. The Florida Marine Patrol reported a whale stranding near North Captiva Island on the southwest coast of Florida (Fig. 1) on the morning of 22 July 1976. Subsequent inspection (1700 hrs.) found a dead female false killer whale at Redfish Pass (Fig. 2), and four live females aground on a sandbar in Pine Island Sound (Fig. 2). The dead animal was necropsied on the beach and the live animals were transported to Sea World, Orlando, Florida (SWF), on 22 July. At least 24 other whales had entered Pine Island

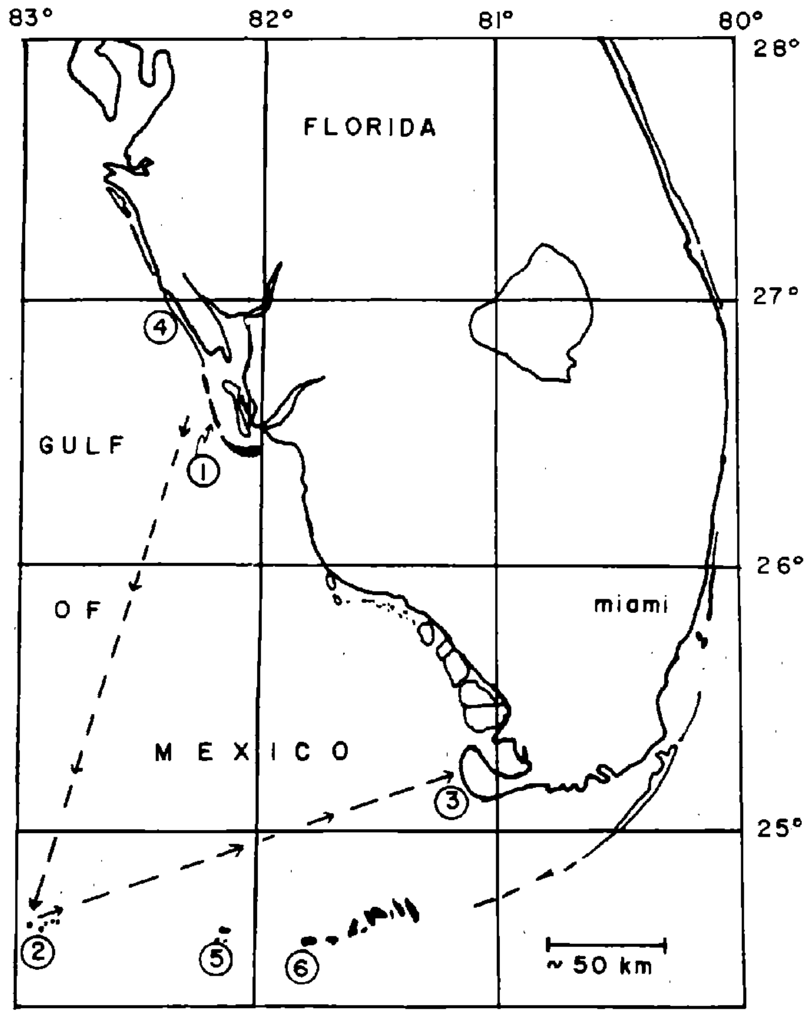

Figure 1. Outline map of south Florida indicating principal stranding sites and possible routes of travel of the false killer whale herd. 1) North Captiva Island; 2) Dry Tortugas; 3) Cape Sable; 4) Manasota Key-Gasparilla Island; 5) Marquesas Keys; 6) Key West. Fort Pierce is located just above 27°N latitude on the east coast of the state.

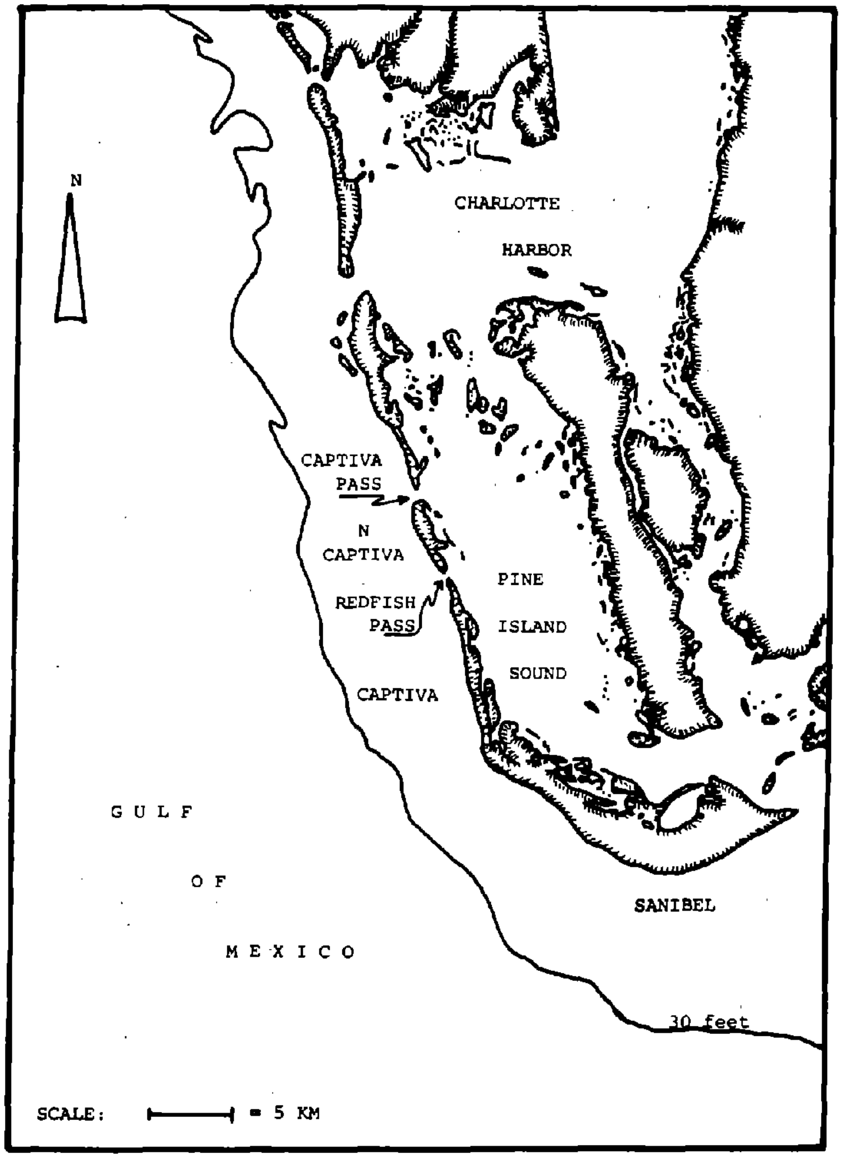

Fig 2

Figure 2. North Captiva Island and vicinity indicating Redfish Pass and Captiva Pass where the false killer whales entered and exited, respectively, Pine Island Sound. The four females taken to Sea World stranded on a sand bar located off the southeast side of North Captiva.

Sound. All moved northward in or near the Intracoastal Waterway after entering Pine Island Sound via Redfish Pass. The remaining 24 continued northward and returned to the Gulf of Mexico via Captiva Pass (Fig. 2). The animals originally entered Redfish Pass at about 0830 hrs.EDT on a rising near high tide.

2. A herd of 30 false killer whales stranded on Loggerhead Key, Dry Tortugas, at approximately 1300 hrs EDT on 25 July on a falling tide, some 235 km south of North Captiva Island. The animals were pushed back into the water and kept wet by U.S. Coast Guard and National Park Service personnel. The animals were measured, sexed, and dorsal fins and flukes photographed on 26 July. This was repeated on 27 July in addition to collecting blood samples and marking each animal with a lobster-style spaghetti tag (G. Davis, pers. comm., 1976). A large male died prior to an attempt to return all of the animals to offshore waters. The remaining 29 were successfully forced out to sea.

3. On 2 August, National Park Service personnel found three shark-eaten Pseudorca carcasses floating about 2 km off Cape Sable (Fig. 1). These were towed to shore and examined on 3 August.

4. Twenty Pseudorca skulls were salvaged from Cape Sable on 28 August. All were severely decomposed and had probably been on the beach for at least two weeks. Sex determination and external measurements were not possible.

Results and Discussion

Morphometrics

All measurements were taken according to Norris (1961) and Mitchell (1975b). Detailed measurements and organ weights were obtained from the animals which died at Redfish Pass, Loggerhead Key and Sea World. Skull

measurements and tooth section have not been completed. Twenty-nine of the 30 whales that stranded on Loggerhead Key were measured (total length only). The mean length of all animals ($n = 29$) was 443 ± 47 cm. The males ($n = 12$) had a mean length of 458 ± 48 cm, range 377-534 cm; and the females ($n = 17$) had a mean length of 416 ± 39 cm, range 328-494 cm. The weight-length data from the four Sea World animals were subjected to linear regression analysis after logarithmic transformation of the variables. The following equation resulted:

Log $y = 3.64 + 2.44$ (log x). $r^2 = 0.99$; where y is weight in kg and x is the total length in cm. The weights of the Loggerhead Key animals were estimated using this formula, bearing in mind that the equation was generated from a small sample size ($n = 4$). Estimated weights ranged from 310 to 1000 kg. The estimated mean weight for the males ($n = 12$) was 694 ± 194 kg; and for the females ($n = 17$) 556 ± 117 kg.

Behavior in captivity

The four live *Pseudorca* transported to Sea World appeared to adapt to captivity with relative ease. When put into their pool, they grouped, swimming rapidly in a clockwise direction with the largest animal apparently leading the group. The animals began feeding on squid, mackerel and herring immediately upon arrival. They consumed adequate amounts of food, often feeding from hand, and were not easily disturbed by routine handling for physical examinations. Within 24 hours after their arrival, both the largest and the smallest animal, were separated from the others and placed in an adjacent pool. Their swimming patterns remained the same but the pace slowed considerably and could be considered more normal (compared with those maintained in captivity). The general behavior and apparent rapid adaptation

to captivity was quite similar to that observed in a captive Pseudorca held at Marineland of the Pacific (Brown et al., 1966; E.D. Asper, unpublished observations). However, all of the animals died within three and one-half weeks.

Necropsies

The necropsies of the six dead whales indicated extensive parasitism. There were abundant acanthocephalan worms, probably Bolbosoma capitatum (Dailey and Brownell 1972), in the small intestine. There were varying degrees of infestation by nematodes in the lungs and pterygoid sinus complex, liver flukes, and stomach nematodes. The smallest animal did not have nematodes in the pterygoid sinus complex. This is consistent with Geraci et al., (1976), who found that the number of Stenurus globicephalae in the pterygoid sinus complex increased with the age in Lagenorhynchus acutus. Notable in our study was the apparent absence in all six animals of cestode plerocercoid cysts in the blubber. The cause of death of the four SWF animals appeared to be pneumonia.

Reproductive condition

Reproductive organs from the six fresh carcasses were examined. The male was judged to be sexually mature on the basis of body length (520 cm) and total testis weight (8200 g). Three of the SWF females were considered sexually immature; their body lengths ranged from 297-358 cm. Neither corpora lutea nor corpora albicantia were found in the ovaries. One SWF female (body length - 475 cm) had three corpora albicantai in the left ovary and five to six in the right ovary (R.J. Harrison, pers. comm., 1977). Total ovarian weight was 46.8 g., three to four times greater than the other three SWF animals (13.3-15.1 g). The female from Redfish Pass(body length-440 cm)

and the presence of corpora albicantia.

Few data are available on sexual maturity and reproduction in Pseudorca. However, using the lower limit of the length range at sexual maturity (Comrie and Adams 1938, Norman and Fraser 1948), only three females from the Tortugas stranding would be considered immature. Using the upper limit, nine females and three males would be considered immature. It is apparent that further data are needed.

Hematology

Blood samples were collected from each of the 30 whales on Loggerhead Key and from the four captive animals. Blood was taken from vessels in the flukes, flippers or dorsal fins. Samples for cell counts, etc., were preserved with EDTA and serum for other analyses was collected and stored frozen after the blood had clotted. Cell counts (RBC, WBC, Hb, PCV, etc.) were done with a Coulter Model D-2. Serum chemistry analyses were done with a Clinicard (Model 368). The data from the 30 Loggerhead Key animals (Table 1) are comparable to hematologic values for other small cetaceans (Brown et al., 1966, Ridgway et al., 1970. Ridgway 1972). Blood values for the four captive animals (Table 2) vary somewhat from the Loggerhead Key group and undoubtedly reflects their deteriorating condition. Serum calcium levels were elevated when compared with other odontocetes. Lactic acid dehydrogenase levels were slightly elevated, and alkaline phosphatase levels were low. Blood urea nitrogen (BUN) and glucose levels were higher in the captives than in the Logggerhead Key animals and could reflect the fact the captives were feeding while the other group had probably not fed for several days.

Table 1. Hematological analyses of blood samples taken from 30 false killer whales stranded on the Dry Tortugas. Collection date: 27 July 1976. For each test: upper values are females, lower values are males.

Parameter	N	$\bar{X}$	S.D.	Range
Hb (g/100 ml)	15	15.9	0.9	14.3-17.1
	11	16.0		14.3-17.2
PCV (hematocrit)	15	46	2	43-50
	11	46	2	43-49
RBC ($10^6/mm^3$)	15	4.06	0.33	3.58-4.81
	11	3.96	0.15	3.74-4.22
MCH	15	39.33	2.02	35.55-42.42
	11	40.56	1.94	37.42-43.85
MCV	15	114.06	4.94	103.95-122.90
	11	116.30	4.03	110.56-123.03
MCHC	15	34.48	0.81	33.12-35.86
	11	34.86	1.11	33.25-36.73
WBC ($10^3/mm^3$)	15	7323	1765	4173-9953
	11	5921	1203	4146-7663
Differential (%)				
Stabs (Bands)	15	1	1	0-3
	11	2	3	0-7
Neutrophils	15	71	14	44-86
	11	72	11	53-88
Lymphocytes	15	14	7	5-27
	11	13	7	3-21
Eosinophiles	15	14	10	0-32
	11	12	10	0-26
Monocytes	15	1	1	0-3
	11	1	1	0-2
Basophils	15	--	--	0
	11	--	--	0
BUN (mg/100 ml)	17	24.6	4.0	15.6-31.5
	12	24.2	6.1	15.4-34.2

Table 1, continued

Calcium (mg/100 ml)	17	11.23	2.27	7.96-15.55
	12	10.00	1.39	7.72-12.85
CPK (IU/L)	17	21	12	6-56
	11	26	22	10-80
Total Chol. (mg/100 ml)	17	219	50	163-302
	12	217	46	173-305
Creatinine (mg/100 ml)	9	0.5	0.6	0.1-1.8
	4	0.6	0.2	0.3-0.8
LDH (IU/L)	17		81	477-733
	12	509	57	429-604
Alk. Phos. (IU/L)	17	107	65	28-231
	12	87	42	40-202
SGOT (IU/L)	17	228	90	133-438
	12	202	88	103-383
SGPT (IU/L)	17	38	63	3-258
	12	50	66	4-251
Glucose (mg/100 ml)	17	77	26	40-136
	12	86	33	45-151
Total Prot. (g/100 ml)	17	7.53	0.43	6.83-8.44
	12	7.71	0.71	6.96-9.20
Albumin (g/100 ml)	17	3.56	0.38	2.92-4.45
	12	3.54	0.31	3.14-4.71
Globulin (g/100 ml)	17	3.91	0.52	2.82-5.00
	12	3.92	0.98	2.67-5.35

Table 2. Hematological analyses of blood taken from four female false killer whales held in captivity for up to three weeks (see Table 1). Mean values over standard deviation, where applicable, in parentheses.

Animal	SWF 627	SWF 628	SWF 629	SWF 630
N	7	7	6	3
Parameter Hb (g/100 ml)	15.0 (0.6)	14.1 (0.6)	13.9 (0.9)	13.5
PCV (hematocrit)	44 (2)	41 (2)	40 (2)	39.00
RBC ($10^6/mm^3$)	3.89 (0.13)	3.88 (0.22)	3.57 (0.21)	3.85
MCH	38.67 (1.91)	36.42 (1.60)	38.91 (1.32)	34.70
MCV	111.96 (3.97)	105.29 (7.03)	112.53 (2.85)	101.44
MCHC	34.53 (0.86)	34.65 (1.39)	34.59 (1.13)	34.32
WBC ($10^3/mm^3$)	6525 (1668)	11153 (4048)	9010 (2383)	7929.67
<u>Differential</u> (%)				
Stabs (Bands)	2 (2)	2 (2)	2 (2)	3
Neutrophils	69 (13)	71 (12)	72 (8)	80
Lymphocytes	20 (8)	18 (5)	15 (8)	13
Eosinophils	10 (7)	9 (9)	11 (9)	2
Monocytes	<1 (<1)	<1 (<1)	<1 (<1)	1
Basophils	0	0	0	0

Table 2, continued

BUN (mg/100 ml)	39.4! (14.0)	46.7! (8.0)	56.3#	43.1
Calcium (mg/100 ml)	8.79! (0.23)	8.62#	8.57@	8.64*
CPK (IU/L)	23! (30)	189¢	134*	77*
Total Chol. (mg/100 ml)	272! (68)	337! (65)	346#	248
Creatinine (mg/100 ml)	0.5¢	0.5#	0.4@	0.7
LDH (IU/L)	396! (69)	392#	373¢	471+
Alk. Phos. (IU/L)	188! (122)	210! (136)	74#	76
SGOT (IU/L)	247 (96)	438 (178)	388	529
SGPT (IU/L)	22! (16)	37! (36)	25#	54
Glucose (mg/100 ml)	186! (68)	163! (52)	142#	179
Total Prot. (g/100 ml)	7.51! (0.49)	7.49! (1.01)	7.20#	6.79
Albumin (g/100 ml)	3.81! (0.38)	3.89! (0.33)	3.68#	3.23
Globulin (g/100 ml)	3.70! (0.25)	3.60! (1.01)	3.32#	3.57

+ sample size = 1

* sample size = 2

¢ sample size = 3

@ sample size = 4

sample size = 5

! sample size = 6

Relationships among strandings

This series of Pseudorca mass strandings was the third in Florida in recent years. Caldwell et al. (1970) reported a stranding of 150 to 175 Pseudorca near Ft. Pierce on the Atlantic coast of Florida in January 1970. No biological data was collected and most of the animals were apparently buried on the beach. A heretofore unreported stranding of 19 Pseudorca occurred on 18-19 July 1972 on the northeast end of Sawyer Key ($24^{\circ}45.6$'N, $81^{\circ}33.4$'W Long.) in the lower Florida Keys on the Florida Bay (Gulf of Mexico) side, approximately 35 km northeast of Key West. Dr. Gordon Hubbell (pers. comm., 1977) estimated the largest animals to be 15 feet (460 cm) long. He measured a 10'6" (320 cm) male, a 12'4" (376 cm) female, and a 14' (427 cm) female.

Judging from photographs of dorsal fins, it is clear that some (and probably all) of the false killer whales that left Pine Island Sound were the same individuals that stranded on Loggerhead Key. Assuming that the animals left Captiva Pass at about 1200 hrs. on July 22, travelling in a straight line, then they travelled about 80 km/day to reach Loggerhead Key at 1300 hrs. on 25 July. When escorted away from Loggerhead Key on 27 July, they apparently headed northeast. The animals found dead on Cape Sable were too decomposed to tell if they too were the Captiva-Tortugas animals.

The sequence of strandings described herein roughly parallels a series of pilot whale (Globicephala macrorhynchus) strandings that occurred in the same vicinity on 19-20 August 1971 (Fehring and Wells 1972).. As in the pilot whale stranding, several of the larger Loggerhead Key Pseudorca were forced off shore (head first without ropes around their tails) in hope that the others would follow. The towed animals returned to the beach when released. The operation was successful only when all of the animals were

forced offshore simultaneously and herded to deeper water using swimmers and two boats. While on the Loggerhead Key beach, the Pseudorca were docile, as Fehring and Wells (1976) reported for the pilot whales. Coast Guard personnel who followed the animals offshore reported that the herd split into two groups (one of 17-18 and one of 10-11) which apparently went in separate directions (R. Schimpff, pers. comm., 1977). It is the general concensus of people at the stranding that the animals headed "northeast." Note that the animals came ashore in two groups.

Conclusions

The cause(s) of these strandings were not determined. It seems reasonably safe to conclude, again, that forcing stranded animals back to sea is a futile effort. If they don't strand again,they may well die at sea and sink. In order to maximize data collection, it may be better to place many of these stranded animals in captivity where they can be observed, treated, and since they will probably die, thoroughly necropsied.

Acknowledgements

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STRESS AND DISEASE IN THE MARINE ENVIRONMENT: INSIGHTS THROUGH STRANDINGS

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BACKGROUND

Population studies on marine mammals utilize data on reproduction, growth and maturation, and mortality. To date, there has been little recognition of the role of disease in each of these facets of an animal's life history. This is not through lack of information on diseases. A wide variety of pathological conditions has been reported both in free-ranging (Stolk 1950, Cockrill 1960, Cowan 1966) and captive (Woodard et al. 1969, Greenwood and Taylor 1977, Sweeney 1974) marine mammals. Ridgway's (1972) review revealed at least 75 disease conditions of varying prevalence, involving all organ systems in cetaceans alone. Yet only a few scattered reports ascribe a functional role to disease in terms of life history.

Stranded animals provide a unique opportunity to study naturally occurring diseases. Advanced diseases are more often apparent in the single stranded animals, perhaps one of the reasons they come ashore. Long-standing conditions such as severe pancreatic disease due to trematode parasites in *Phocoena phocoena* (Delyamure 1955) give an indication of the magnitude of the disease burden they can actually tolerate. *Delphinus* sp. seem to maintain moderately good body condition despite severe brain damage by *Nasitrema*, of some duration. This tenacious behaviour, referred to as "staying power", makes it difficult to interpret the health status of an individual or population, and to define the limit of tolerance, beyond which an animal can no longer cope with its ailment. It is at this level, that stress plays a key role in the delicate balance of survival.

Mass strandings are useful from another point of view. They present the opportunity to survey a cross section (though sometimes biased) of a population, in which the development of disease processes can be charted in relation to age and sex. They also provide an indication of various disorders normally present in "healthy" free-ranging populations. This presumes, and with some supporting evidence, that the stranding event is unrelated to many of the conditions. Mass stranders also provide data on tissue burdens of pollutants as an index of ongoing environmental contamination, against which future impact can be assessed. Parasites are important too, not only in relation to the reaction they invoke in the host, but also as biological tags useful in differentiating sub-populations.

This paper deals with specific examples of how disease data gathered from stranded pinnipeds and cetaceans can be used to augment our knowledge of natural history.

AGE AND DISEASE

Infection by specific parasites, at an early age, accounts for mortality in some species, especially pinnipeds. The picture is becoming clear through strandings. In a recent survey in New England of 94 stranded harbor seals, we found that 35% had respiratory tract infections caused by the nematode *Otsotrongylus circumlitus*. Forty-three percent of the seals, including most of those with lungworms, also had heartworms, *Dipetalonema spirocauda*. Lungworms are virtually absent in seals over two years of age, and heartworms do not, at least in the stranded population,appear to be a serious problem of older seals. There are two possible reasons. The diseases may be self-limiting, that is, young animals die as a result of the infection, or eventually establish immunity which protects them from reinfection. Alternatively, changing feeding patterns, with age, may decrease infection rate in older animals. While all these factors may operate in lungworm infection, it is unlikely that the latter scheme would apply to heartworms as they are most likely transmitted by an arthropod vector, rather than through the food chain.

California sea lions, *Zalophus californianus*, seem to follow a similar pattern of age-related parasitic disease. Pups become infected with the miniscule lungworm, *Parafilaroides decorus*,soon

after they begin to experiment with prey-feeding (Dailey 1970). The worms cause obstructive respiratory disease. Pups severely weakened by *Parafilaroides* characteristically come ashore in late summer and fall. Unlike *Otostrongylus* of harbor seals, *Parafilaroides* infection persists in older animals, but in a slightly different form - as a stress associated disease.

Stranded cetaceans provide some interesting examples of age-related findings, with variable influence on disease. For example, by utilizing two mass strandings and a number of individual strandings, it was possible to map the age at first occurrence of a variety of parasites in the Atlantic white-sided dolphin, *Lagenorhynchus acutus* (Geraci et al. 1976; Fig. 1). Many of the parasites appeared to be rather innocuous, and could be readily discounted from the point of view of disease. However, since most are presumed to have been taken in as part of the food chain, their first occurrence in the host is necessarily linked to the age of weaning or of first food gathering. Furthermore, differences in the time of first occurrence between the various parasites, i.e. *Phyllobothrium sp.*, *Tetrabothrius*, and *Monorygma*, (Fig. 1) reflect either changing food habits with age, or considerable variation in the maturation of the parasite within the host.

A different age-related pattern of parasitic infection emerges with the spirurid nematode *Crassicauda* sp. These parasites are found within innocuous tissue tracts in the fascia underlying the blubber along the lateral body wall. Viable nematodes are found

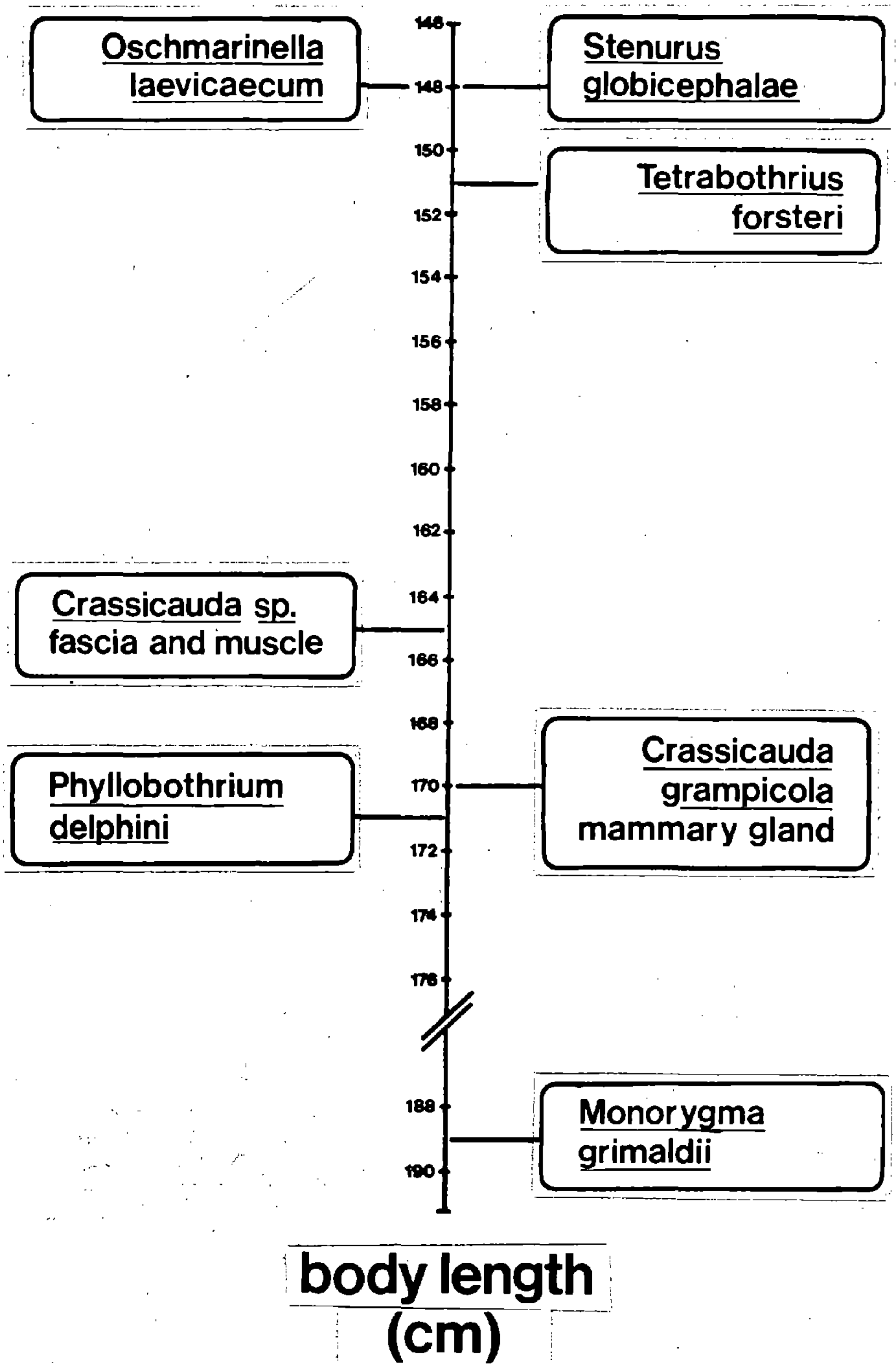

Fig. 1 Dolphin length at first appearance of the major parasites of L. acutus. All animals were two years of age, or less.

in fresh tracts in young dolphins only, while only calcified remnants of tracts are apparent in older animals. Though harmless in their migrating stage, they may have more menacing potential at their final destination. A principle target organ for this parasite is the mammary gland. Seventy-seven percent of 30 stranded female L. acutus had mammary lesions grossly or microscopically associated with Crassicauda grampicola (Geraci et al. 1978a). Their presence is associated with significant organ damage which likely results in functional impairment, possibly sufficient to interfere with calf nutrition. Accordingly, severe damage may hamper reproductive success of the female. In terms of life history, this parasite may limit sexual productivity in advance of the more conventionally accorded age of ovarian senility.

SEX AND DISEASE

There is an obvious relationship between mammary gland parasites and females. But many other parasites, not associated with sexual organs, also seem to have some predilection for females, at least in L. acutus. In a stranded population of this species, intensity of infection with T. forsteri, M. grimaldi, and P. delphini was greater in females than in males (Geraci et al. 1976). By contrast, Dailey and Perrin (1973) had nearly equal infection of Monorygma sp. in Stenella graffmani, and a greater burden of P. delphini in males. The larger parasite burden in female L. acutus might correlate with greater feeding intensity of females because of presumably higher food demands

associated with reproduction. Apart from this, stranding data strongly points to sex segregation of adult L. *acutus*, and differences in parasite burden may reflect differences in food stocks, and therefore larval parasite availability.

A STRESSFUL SEA

Stress is a physiological and biochemical response to changing environmental demands. The adrenal gland features prominently in the response. We can only speculate on the mechanisms and potential effects of stress in free-ranging marine mammals. Nevertheless, it has been possible to gain some insight and establish criteria for the evaluation of this rather non-specific phenomenon. On the basis of a survey of adrenal glands taken from several stranded cetacean and pinniped species, we now recognize certain features of adrenal morphology which apparently predispose the outer layer or cortex to pathological changes. In L. *acutus*, the immature adrenal cortex is highly lobulated with pallisading connective tissue trabeculae. As the animal matures, the trabeculae become thicker and fewer in number. The nests or clusters of cortical cells, which accompany the lobular arrangement in young animals, develop into larger cortical nodules, displacing and compressing adjacent normal secretory tissue. In the extreme, this results in massive fluid-filled cortical cysts, either through sinusoidal blockage or hyper-secretion. The net result is a gland that is morphologically and, presumably, functionally impaired. Since the

affected areas characteristically secrete steroid hormones, which function in a host of vital metabolic processes such as salt and water balance, glucose and protein metabolism, and reaction to stress, loss of normal activity can result in far-reaching problems. Adrenal cortical activity and development are under central stimulation by the pituitary and hypothalamus, and as such, changes in the paired glands are usually symmetrical. L. acutus shows a different pattern, in that of 6 animals in which large cortical cysts were noted, the left gland was the only one affected. The reason for this unusual bias is not known, but may lie in differences in the embryological development or in vascular patterns between the paired glands.

Though morphology seems to predispose the adrenal glands to abnormal development, the root probably lies in stress. In this regard, a unique facet of the condition is that mature females seem to bear the brunt of the problem. Only one of five adult males had microscopic cysts. Yet the same condition was observed in 100% of 20 adult females. Moreover, 75% of them had cysts which could be observed grossly; these were not noted in males. This mature female bias may tie in with features such as the observed higher parasite burden or other less obvious factors, associated perhaps with the demands of reproduction.

We must assume that most of the conditions noted in free-ranging marine mammals are not in themselves life-threatening. Established parasites, as numerous as they may be, fall within

this category. It is only when an animal is weakened, or in some way stressed, that the conditions take on a more serious role. For instance, we have noted marked differences in response to environmental pollutants between seals which have been newly captured and those which have been subjected to the stress of extended captivity (Geraci and Smith 1976). One of the most critical problems facing phocid seals in captivity is hyponatremia, a metabolic condition, which has stress as an underlying basis. This adrenal-mediated problem has been induced experimentally through a wide variety of manipulative procedures, but has also been observed during moult and in free-ranging ringed seals in poor body condition (Geraci et al. 1978b).

We have no laboratory documentation of stress in cetaceans. However, observations in stranded animals, such as adrenal cortical atrophy in debilitated *Phocoena*, as well as the striking adrenal findings in *L. acutus*, are beginning to focus onto the stress response as an essential component of survival in the marine environment. For some species which adapt poorly to captivity, such as *L. acutus*, strandings may provide the only valuable clues to stress, and its relationship to disease and life history.

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Abstract

NEUROPATHOLOGY IN RELATION TO STRANDINGS.

CAPTIVE AND SINGLE STRANDED CETACEANS

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A study of cetacean brain disease has been in progress for nearly 3 years. With the cooperation of the Aquarium and Zoological Gardens in St. Petersburg Beach, Marineland of Florida in St. Augustine, and Sea World in Orlando, brains of both captive and wild cetaceans have been examined. Two cases, one each of a cerebrovascular disorder and an infectious disease will be described in some detail.

The first involves a 244 cm Atlantic bottlenosed dolphin (Tursiops truncatus) found to have suffered from a massive, intracerebral hemorrhage. Examination of the surface of the brain did not show any gross abnormalities, however, one centimeter coronal sections revealed an extensive hemorrhage in the right hemisphere. Numerous small satellite hemorrhages were evident in the necrotic tissue tissue adjacent to the main hemorrhagic mass which extended rostral and laterally into the lateral ventricle. Despite extensive examination involving many different stains, no evidence of infection, neoplasia, arteriovenous malformation or parasitic infestation was found. Traumatic intracerebral hemorrhage was considered unlikely as the lesion occurred in a portion of cerebral cortex which is not subject to abrasion or contusion by a bony skull projection; no contusion or hemorrhage was present over the surface of the cerebral hemispheres and no skull fracture was present at autopsy. Although it cannot be proven, the

case is suggestive of hypertensive hemorrhages which occur commonly in man.

Three other cases involving cerebrovascular disease include a recent case of arterial thrombosis in a captive dolphin from Marineland, subarachnoid hemorrhage in the cerebral cortex of a beached bottlenosed dolphin, and subarachnoid hemorrhage over the lower brainstem of a captive dolphin from Marineland.

In addition to cerebrovascular disorders, cetaceans are also susceptible to infectious brain disease. In 1975, a 188 cm female spotted dolphin, probably Stenella plagiodon, was found dead on St. Petersburg Beach, Florida. It had chronic meningitis. Grossly the brain was in pieces with severe postmortem necrosis. Venous enlargement was observed, however, there was no other gross pathology indicative of the meningitis. The gyri did not appear swollen and there was no observable exudate over the external brain surface.

Careful evaluations have not revealed parasitic infestations in the brains of single stranded animals. We have observed one animal with a xanthogranuloma at the entrance of branial nerve VIII in the adjacent cerebellar tissue, however, this chronic lesion did not have any identifiable parasites. We have not found evidence of degenerative brain disease in cetaceans, other than cerebral changes of aging. We have observed accumulation of lipofuscin pigment in the neurons of some of the larger animals.

NEUROPATHOLOGY IN RELATION TO STRANDINGS

MASS STRANDED WHALES[1]

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Introduction

A study of single stranded and captive cetaceans has revealed a relatively high incidence of neurologic disease. Massive intracerebral hemorrhage (Hall *et al.*, 1977), chronic meningitis and granulomas possibly associated with past parasitic infection have been found during a three year survey of Florida animals. A high incidence of parasitic lesions has been reported following autopsies of single stranded cetaceans in California (Ridgway, 1965; Ridgway and Johnston, 1965; Johnston and Ridgway, 1969; Ridgway and Dailey, 1972; Schroeder *et al*, 1973). As a consequence of these findings, it is possible that some mass strandings are the result of herd members suffering from brain disease. To examine this possibility, autopsies were performed on brains from representatives of a *Stenella longirostris* mass stranding (Casey Key, Florida, 1976), two *Pseudorca crassidens* mass strandings (Sanibel Island, Florida, 1976; Loggerhead Key, Florida, 1976) and one *Globicephala macrorhyncus* mass stranding (Fort George Inlet, Florida, 1977).

Methods

Brains were removed after cutting away the calvarium overlying the cerebellum and parietal-occipital lobes of the cerebral hemispheres. When removed within a few hours after death, the brains were fixed by submersion in 10% buffered formal-saline. Brains already undergoing autolysis at the time of removal were placed in 50% formal-saline until the tissue sank. They were then transferred to 10% formal-saline. In most instances, the brains were wrapped in cheesecloth and suspended in the fixative in order to preserve the original shape and to avoid artifacts due to contact with the container. After a minimum of 10 days fixation and several changes of formalin, the tissue was examined for gross pathologic changes. The cerebellum and attached brainstem were removed from the cerebral hemispheres which were oriented so that 1 cm coronal sections would pass in a plane perpendicular to the frontal-occipital axis. Sections through the cerebellum and brainstem were made perpendicular to the rostral-caudal axis of these structures. Areas suspected of having undergone pathologic change, as well as sections of cerebral cortex, hippocampus, cerebellum, 8th cranial nerve and pontine-cerebellar junction at the entry point of the 8th cranial nerve were taken for histologic evaluation. These sections were examined using hematocylin-eosin stain. In cases where autolysis precluded histologic evaluation, conclusions were based upon gross examination of the tissue.

Results and Discussion

Stenella longirostris (Casey Key, Florida, 1976)

Twenty-five animals were examined for neuropathology following the Stenella longirostris mass stranding on Casey Key, Florida on July 13, 1976.

Most of the brains examined were severely autolytic at the time of autopsy. There was no evidence of ante-mortem infection, trauma, or

parasitism involving the brains, including the seventh and eighth cranial nerves and vestibular-cochlear nuclei.

Several of the animals had localized subarachnoid hemorrhages over the brainstem and cerebellum, while one individual was found to have a small hemorrhagic mass in the left thalamic nucleus with additional blood over the dorsal aspect of the corpus callosum. Microscopic examination revealed that the blood was relatively fresh in all of these cases, indicating that the hemorrhages most likely occurred after the stranding.

Pseudorca crassidens (Captiva Island, Florida, 1976)

Two of the five *Pseudorca crassidens* that came ashore near Captiva Island, Florida, during the summer of 1976 were evaluated for neuropathology. These two individuals were part of a group of four animals maintained for several weeks at Sea World, Florida, following the stranding (Odell *et al*, these Proceedings). Although *Stenurus sp*. were found in the middle ear cavities of these individuals, gross and histologic evaluation of the 8th cranial nerves and pontine-cerebellar junctions revealed no evidence of parasitic infiltration. All other brain regions were also free of parasites.

Pseudorca crassidens (Loggerhead Key, Florida, 1976)

One large male *Pseudorca crassidens* died at the time of the Loggerhead Key mass stranding a week after the Sanibel Island incident. This individual was observed listing in the shallow waters and experiencing difficulty breathing . There was also a possibility that this animal was one of several observed vomiting in the surf. These symptoms could have been the result of an inner ear dysfunction. Examination of the entire length of each 8th cranial nerve of this individual revealed numerous parasites along the bony canals ensheafing the auditory nerves. Grossly, these parasites were found extradurally, but there was no gross or histologic evidence that they had

penetrated the dura to the central nervous system. Whether or not the Stenurus sp. had infiltrated the semicircular canals and caused damage to the hair cells is still under investigation by Drs. Woodard and Popp of the University of Florida College of Veterinary Medicine. Except for a hemorrhagic mass associated with the venous circulation in the medullary region of the brainstem, there was no central nervous system pathology. It is not known whether these hemorrhages, which have been observed in other species, are pathologic and possibly due to hyperthermia and dehydration, or simply artifact. There was no evidence of concommitant neuronal change associated with the hemorrhage.

Globicephala macrorhyncus (Fort George Inlet, Florida, 1977)

During the evening of February 5, 1977, a large group of pilot whales swam through the narrow entrance of Fort George Inlet, Jacksonville. Of the 150-200 animals that stranded, 8 were examined for neuropathology. All of the brains appeared grossly normal. Microscopic examination of the tissue also failed to reveal any evidence of disease. Stenurus sp. were found in the middle ear cavities of certain animals; however, there was no evidence of parasitic infection within the central nervous system.

Conclusions

A four year sutdy of single stranded and captive animals has revealed certain cerebrovascular and infectious disease in these cetaceans. To date, no evidence of major neurologic disease has been found in mass stranded cetaceans. Seldom has the tissue been fresh enough for extensive histopathology and, when it was, logistical barriers permitted a survey of only certain representative animals during the short time that the material was salvagable. Many of the initial difficulties have been overcome.

Experience in salvaging tissue under a wide variety of conditions has enabled us to modify our fixation procedures and thereby increase the scope of our studies.

Whenever possible, an attempt should be made to utilize the material for purposes other than simply a descriptive study of brain disease. This is currently being done. A large amount of both normal and pathologic brain material is available for teaching purposes at the University of Florida College of Veterinary Medicine. Some of the tissue recovered is also being used for reproductive-neuroendocrine studies being conducted at the same institution, as well as for studies of the visual system at the University of Florida College of Medicine. Brains have also been made available to other institutions in the U.S. for teaching and research purposes.

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Footnotes

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Abstract

PARASITES AS AN AID TO UNDERSTANDING MARINE MAMMAL POPULATIONS

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Previous work on parasites as biological indicators of various types has been carried out on many terrestrial and aquatic animals. Information gained on the origin of salmon populations through parasitic tagging is well known by fisheries management workers.

In 1972, Ridgway and Dailey reported on parasites and their possible role in strandings. Since that time parasitic helminths have received a great deal of attention in the preparation of stranding material. If the formation of an organized stranding network such as proposed at this symposium becomes a reality, much can be done in the way of parasites as indicators of marine mammal populations.

Parasites as tags, presents the following possibilities:

1. An indicator to the migration and feeding habits of wild populations.

II. A means to separate intraspecific variation of inshore and open water populations.

III. Give an indication as to the general state of health in the various populations.

IV. Enable investigators to compare regional findings and a means to assess cause of mortality in these areas.

The end result of these various activities would substantially contribute to our overall objective of marine mammal management. The use of parasites as biological tags would of course be only one tool in which to solve these problems.

This work is not possible at present due to the lack of good, consistent data on all stranding material, differences in methods of specimen preparation and general insufficient coordination of overall research efforts in stranding studies.

Abstract

STUDIES OF MYOGLOBIN FROM STRANDED CETACEANS AS A CONTRIBUTION TO UNDERSTANDING MARINE MAMMAL POPULATIONS

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The oxygen-bearing muscle protein myoglobin is plentiful in marine mammals. It consists of a heme component which combines reversibly with oxygen when held within the folds of the protein chain. This chain consists of 153 amino acid residues connected in a linear sequence. The ordering of these amino acid residues is determined by a specific gene. Little variation can be expected within a species or between closely related species, whereas appreciable differences can be recognized between more distantly related species. The amino acid sequences of eleven cetacean myoglobins have been completed in this laboratory and four more are in the process. The amino acid sequence data have been analyzed and correlated by computer techniques to construct phylogenetic trees.

Four mysticetes (fin, sei, minke and California gray whale) group together in clear separation from the odontocetes. The latter divide into more than one group. The *Phocoenidae* (2 species) are clearly separated from the *Delphinidae* (4 species) and each of these families is distinct from the river dolphins as represented by *Inia geoffrensis*. Clearly separate from all these forms are the *Ziphiidae* (represented by one species) and the *Physeteridae*, represented by the sperm whale and *Kogia simus*. The tree generally agrees with other taxonomies. In addition to setting up the

broad categories, it places Inia close to a common ancestor for porpoises and dolphins; it places the baleen whales very close to each other; and it likewise shows very close relationship among several delphinids.

This work can be extended usefully in two directions. First, the general phylogentic picture should be filled out with representatives of the families Balaenidae and Monodontidae, and with representatives of any other species whose family relationships could be usefully elucidated. Second, the extent of variations within species should be explored by sequence analysis of myoglobins extracted from frozen muscle tissue.

Myoglobin sequence analysis has proven to be a valuable tool in defining general taxonomic categories. Since some intraspecific variations in myoglobin probably exist, these may well provide a biochemical basis for distinguishing between individual, genetically isolated breeding populations. A further benefit of these kinds of studies is that the source material is relatively stable and can be obtained from stranded animals. Individual strandlings will help to fill in existing gaps in data in terms of mammals generally, and mass strandings may provide the best single source of data relevant to segregation of sub-populations.

RECOVERY AND CARE
OF STRANDLINGS

MARINE MAMMAL STRANDINGS:

ON SITE PROBLEMS AND SOLUTIONS

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BACKGROUND

Stranded marine mammals pose a variety of problems for the individual or institution responsible for recovery and disposal of specimens. Potential areas of difficulty range from abiding by various regulatory statutes imposed by the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and regional or local codes, to the logistic difficulties in dealing with large numbers (mass stranding) or types (great whales) of specimens. This paper attempts to address major problem areas, and provide some practical solutions for on-site handling of stranded animals.

LOCATING STRANDLINGS

Strandings often occur in relatively remote or inaccessible areas, or in locations that are unfamiliar to the dispatch team. The problem can be further complicated by inaccurate description

of the stranding site provided by the observer or notifying party. It is important, then, before dispatching a team, to obtain accurate and detailed information so that specimen(s) can be located even under adverse weather, visibility, and light conditions. The notifying party should furnish details on:

- description of the animal, with emphasis on size (weight descriptions are invariably inaccurate)
- duration of the specimen on the beach (this provides some indication of the urgent nature of the problem)
- description of the stranding site (sandy beach, sharp-cusped rocks, etc.)
- distance and accessability to a conventional roadway,
- suitability for an appropriate vehicle.
- nature and availability of on-site assistance (personnel, vehicles, boats); obtain name and telephone number of local contact.

After recording this information, and before dispatching a team, an attempt should be made to notify the law enforcement agency with jurisdiction over stranded animals in the area, and make arrangements to procure the specimen(s). (Once contacts with law enforcement agencies have been firmly established, this procedure often is no longer required).

The on-site team should be equipped with a copy of the reported stranding details, appropriate Geological Survey or equivalent topographic maps, and a nautical chart of the area. Depending on animal size and accessibility, the team may require an ordinary automobile, a 4-wheel drive vehicle (with winch), or a large sturdy

truck. A crane or other suitable lifting device may be required ultimately to perform the task of animal removal/burial. Be prepared to rent such equipment.

A boat can be useful, especially in mass strandings, when gathering animals scattered about in tidal marshes and estuaries. A list of marinas in the area should be obtained, noting those that are seasonal.

HANDLING LIVE STRANDLINGS

Pinnipeds

All pinnipeds should be approached cautiously. Once it is deemed that the animal is beached, i.e. unable or unwilling to return to sea when approached, it should be restrained with a net. Almost any net configuration is suitable for a small phocid seal, i.e. stretcher net, hoop net, throw net, whereas the more maneuverable otarids are best restrained with some type of hoop net. Netting will not prevent an animal from biting - avoid the head area. Once netted, the animal can be moved on a net stretcher or placed in a suitable well-ventilated enclosure. Overheating must be avoided at all cost.

Cetaceans

Large whales are almost impossible to work with when they are stranded alive. For lack of a suitable alternative, an attempt may be made to return it to sea. If the animal cannot be moved easily, avoid dragging it on the beach, as the resulting damage will further jeopardize its already slim chance for survival.

It should be kept free of rough surf, maintained wet with towels or rags, and shaded from the sun. A wet cloth covering is better than running water; it not only shades the animal from the sun but also holds water evenly and provides better evaporative cooling. The blow hole and exposed areas may be protected with lanolin. Covering the eyes may help keep the animal calm. Noise, crowding, and unnecessary handling should be avoided.

The only practical method of returning a large whale to sea is towing it by the tail. This requires that a large boat be able to get in close to shore. Towing can be hazardous to both the vessel and crew, and should be undertaken with caution. The line should be non-abrasive (braided nylon is best) and tied around the flukes with a loop wide enough so that it can be shed if the whale escapes before the line can be removed. A line left on the flukes may cause chafing and erosion, or become tangled.

Before towing, it is helpful to establish breathing rate. While the animal is being towed the rate can be monitored and towing stopped or slowed if the interval becomes too long. Some fluctuation in breathing rate can be expected when a whale is being towed. Towing should proceed so that the head of the animal is not pulled underwater.

Before the whale is released, an attempt should be made to measure and sex it. Photographs are also useful in the event of restranding. Tagging is desirable as well, but this is difficult under present legislation.

It is reasonable to assume that stranded animals returned to sea will probably not survive, and may restrand. Euthanasia is a reasonable alternative, but poses problems with regard to public pressure, and legal responsibility of the individual carrying out the procedure.

Smaller cetaceans can often be held in water while waiting to relocate them. If one is to be moved only a short distance, it is sometimes easier to "walk" it in the water, rather than to carry it. This can be done with or without a stretcher. Larger cetaceans require a stretcher. Netting, sheets and clothing can be used to improvise a stretcher. When no stretcher is available and the animal cannot be supported in the water, it may be placed on a sand beach, and a hole dug around it to distribute its weight evenly. As an alternative it can be rotated from side to side at 15 minute intervals.

DEAD STRANDLINGS

Depending on the condition of the carcass, dead animals should either be removed to a laboratory or buried. If the carcass is decomposed, a quick inspection on the beach can gather valuable information such as sex, morphological data, stomach contents, gross lesions, parasites, reproductive condition, and a confirmed identification. For example, a Grampus that had been buried for a year yielded the following information: standard measurements except girths, stomach

contents, sexual maturity and parasites (blubber plerocercoid cysts and cranial sinus nematodes).

It is obviously more desirable to transport dead animals to laboratory facilities for examination. This can be done easily with small specimens. They must be wrapped as well as possible to minimize leakage when transporting. Body bags are useful though the zippers sometimes leak. Those with handles can be used in place of a stretcher by putting poles or shovel handles through the body bag loops. Wire basket stretchers can also be employed in removing small dead animals. Body bags sag and are more difficult to manage.

Large animals pose a problem. Marinas with boat lifts or ramps, or other suitable lifting equipment, can be used to remove an animal onto a truck. As a poor alternative, observers can sometimes be pressed into service to lift an animal by rolling it onto a blanket or tarpaulin, and then onto a truck for eventual transportation. A boat trailer can also be used as a transport vehicle. One that tips to the ground makes it easier to get the animal in by dragging it with a ratchet come-along, or block and tackle.

CARCASS DISPOSAL

Once the decision has been made to dispose of the carcass, a number of alternatives are open. First, it is important to

obtain photographic records, emphasizing side views for species identification, ventral views for sexing, and close-ups of head, appendages, and irregularities such as wounds, scars, etc. Obtain tissues and specimens according to the procedures outlined on p.28-31 of this text.

It is best to make the necessary arrangements for disposal before working on an animal. The person accepting responsibility for disposal should know what it entails. These are the options:

1. Towing the animal out to sea is very costly and unless the carcass is taken beyond the variable coastal currents, it is likely to wash up elsewhere. Before towing, the abdomen should be opened to accelerate deterioration. A decomposed carcass has gas accumulated in the tissues, and to sink it, it will have to be weighted. It can take months for an animal to decompose to the point where it no longer constitutes a hazard to navigation.

2. Burial at the site of the stranding is the best solution. The question usually is whether it is easier to transport burial equipment to the whale or vice versa. If the stranding site is unsuitable, other areas to consider are dumps or sanitary landfill areas. The equipment used for burial can also be employed during the necropsy for turning the animal, lining animals up, weighing, etc.

The burial hole must be deep or the carcass may resurface. During the process of decomposition the animal remains collapse,

leaving a large hole. This can be avoided by cutting up the carcass before burial.

3. Rendering plants will sometimes take the remains, though the legal status of this means of disposal needs to be clarified. The only drawback is that the pieces have to be fairly small to feed through the equipment. If large amounts of material are involved, it is sometimes possible to get personnel assistance from the plant.

4. Attempts to burn or explode carcasses have been comically disasterous.

PUBLIC RELATIONS

The stranding team may encounter problems relating to the ownership of and responsibility for stranded animals. The traditions applying to salvage of material that drifts up on the beach (i.e. usually the property of the finder), do not apply to stranded marine mammals. The laws can usually be explained to persons wishing to exercise claims of ownership for trophy or other purposes. The National Marine Fisheries Service or local authorities are legally responsible in these cases and should be consulted if there is a persistent problem.

Dead animals can be a nuisance or a health hazard. In the absence of clear legal guidelines, disposal is basically the problem of the authority in control of the beach. In the past, the Coast Guard and the National Marine Fisheries Service have been helpful in this regard, though they have no legal obligation.

The team working on an animal should accept some responsibility for its disposal. It is always best to work this out beforehand with the beach authorities. If properly handled, this can result in favorable and very useful public relations. Improper handling of the situation can compromise future studies.

The question arises as to public health hazard of decomposing material. The possibility of contamination exists; as yet no specific problem has been identified, and this would not be considered a high risk issue.

If the stranding is at all unusual, public demand for information becomes acute, often reflected in pressure from the local news media. While this may seem a fairly minor consideration, it does represent a chance to educate and gain positive public reaction and support. A situation improperly handled can easily create negative press and public reaction. It is generally possible to handle inquiries as they arise. We have found it useful to provide local news media with basic information, i.e. identification, length, sex, weight, and plans for the future use of the animal, as well as a brief explanation of natural mortality and strandings generally. So as to maximize efficiency, it is best to delegate one person to deal directly with the press.

It is a good policy to provide follow-up reports on strandings, once most of the pertinent data becomes available. Letters to the local police, the Coast Guard and the press explaining what has been found will be appreciated and will pave the way for cordial cooperation.

Crowd control is a problem. The National Marine Fisheries Service is very effective in explaining the law enforcement aspects of beached animals and local authorities are helpful in limiting access to the area.

LEGAL PROBLEMS RELATING TO PROTECTION OF MARINE MAMMALS

The regulations pertaining to scientific work involving stranded marine mammals remain somewhat unclear. All such animals are covered by the provisions of the Marine Mammal Protection Act of 1972 (50 CFR part 216). In addition, those animals listed by the United States as endangered are covered by the Endangered Species Act of 1973 (50 CFR part 222). This Act includes all of the larger whales except *Balaenoptera edeni*. Marine mammals to be imported are also covered by an additional series of regulations which are beyond the scope of this paper.

While it is unclear how certain portions of these Acts relate to stranded marine mammals, it has been the general policy of the federal enforcement agency (National Marine Fisheries Service) that a federal permit is required to collect specimen materials. It is strongly suggested that persons or institutions who contemplate regular involvement with stranded marine mammals obtain such a permit. Information or applications can be obtained from the National Marine Fisheries Service, U.S. Department of Commerce, Washington, D.C. 20235. This of course does not cover state or local regulations which may apply to marine mammals or wildlife in general.

Lacking a federal permit, the following sections of the Marine Mammal Protection Act may apply. Section 216.22 deals

with taking of marine mammals by state and local officials, and essentially states that if it falls within the line of duty, such officials may do as they see fit with marine mammals. This section of the Act has been variously applied, but potentially gives state agencies control over strandings, and means that if, for example, a state wildlife officer feels that it is within the "normal course of duty" to deal with a stranded marine mammal, he/she may dispose of it by turning it over for research. In addition, section 216.26 of the Marine Mammal Protection Act authorizes any person to collect bones, teeth, or ivory from any dead marine mammal, "from a beach or from land within 1/4 of a mile of the ocean". Such collection must be registered with the National Marine Fisheries Service or the Bureau of Sport Fisheries and Wildlife (Department of the Interior) within 30 days. This quite clearly covers the collection of osteological specimens for museum purposes, but does not cover collection of soft parts for scientific research. However, in this regard it has been the general policy of the National Marine Fisheries Service to cooperate fully with the scientific community. The Marine Mammal Protection Act does have provisions whereby specimen material can be obtained without a permit *per se*. The Endangered Species Act, however, has no such provisions and research on species under its coverage clearly will require a permit.

EQUIPMENT

Data forms (see pages 25-26 of these Proceedings).
Rapidographs or suitable writing implements
Clip boards (covered medical type, $15)
Tags (use 100% rag or plastic based paper)
String (nylon string, 60 lb. test braided squidding line seems to be the best)
Whirl packs, enough so that you can double bag with tag in outer bag (NASCO, $40/500)
Knives, stainless steel, large and small, probably about a dozen
Sharpeners, diamond steels are the best (EZE-Lap, $50)
Boxes with a liner, foam coolers
Formalin and other fixatives
Hooks for holding back blubber and rolling the animal-very important for large animals
Coveralls with pockets
Boots
Slicker outfit
Warm, waterproof gloves
Scales (Chatillon makes a good series of metric scales, up to 2,000 kg.)
   Large scale for whole bodies $350
   Small scales for tissue weights $20-40
Camera and film
Scalpel blades and holders
Tire pump or tire inflation cylinder
Rachet come-alongs (3/4 to 1 1/2 ton, $50)
Body bags ($25-40) (we have found transport coffins to be very useful $60-150)
Maps
CB radios
Axion (enzyme detergent booster)
Heavy plastic bags (15 ml plastic tubing can be used for making bags, 36-48 inches in width)
Shipping labels
Identification card
Assorted ropes and chains
Flensing knives
Tarps, 8 by 12 heavy canvas - useful for stretchers, covering animals, wrapping large specimens
Stretcher

SELECTED LENGTH/WEIGHT VALUES FOR VARIOUS CETACEANS

- Mysticetes
  - Balaenids
    - *Balaena glacialis* 1550/42000*
  - Balaenopterids
    - *Balaenoptera borealis* 1360/16080 1430/16000
    - *B. acutorostrata* 317/295 388/552 422/590 690/6740 830/7650
    - *B. musculus* 2718/122000 2760/190000 2870/140000
    - *B. physalus* 530/993 614/1814 665/2223 1800/42310 2165/59394
    - *Megaptera novaeangliae* 1000/10886 1250/37195 1344/39916
  - Eschrichtiids
    - *Eschrichtius robustus* 815/6350 1335/31466

- Odontocetes
  - Physeterids
    - *Physeter catodon* 377/553 498/1650 760/4500 1060/11300 1795/53365
    - *Kogia* sp. 131/33 163/82 237/209 270/408 360/517 420/635
  - Ziphiids
    - *Berardius bairdii* 1080/7500
    - *Mesoplodon densirostris* 397/848
    - *Mesoplodon* spp. 420/699 473/1012 532/1429
    - *Ziphius cavirostris* 570/2268 580/2540 580/2535
  - Delphinids
    - *Delphinus delphis* 143/32 172/58 185/60 195/77 206/100
    - *Globicephala melaena* 269/294 up to 3000 kg.
    - *G. macrorhynchus* 223/180 268/270 330/570 403/830 437/1220 502/1660
    - *Grampus griseus* 168/37 360/544 370/470 360/628
    - *Lagenorhynchus acutus* males 126-267/24-234 females 128-236/29-182
    - *L. obliquidens* 138/95 221/100 223/180
    - *Orcinus orca* up to 8000 kg
    - *Pseudorca crassidens* 523/902
    - *Stenella coeruleoalba* 113/13.2 158/41 183/66
    - *S. longirostris* 138/27 175/54

SELECTED LENGTH/WEIGHT VALUES FOR VARIOUS CETACEANS continued

S. plagiodon	120/20	192/79					
Steno bredanensis	204/76	211/101	221/121	227/149			
Tursiops truncatus	111/16	127/27	154/54	176/73	184/93	201/103	
" " " "	206/141	216/145	233/172	252/220	256/230		
Phocoenids							
Phocoena phocoena	84/6.8	100/14	128/25	168/74	169/89	173/70	179/75
Phocoenoides dalli	184/84	189/94	200/114				

* The data are expressed as length (cm)/weight (kg). Values are from various literature sources and MMSP files (Smithsonian).

NURSING CARE OF STRANDLINGS

Florida Manatees, *Trichechus manatus*

E.D. Asper
Sea World
Orlando, Florida

Since 1974, Sea World of Florida has responded to calls from the United States Fish and Wildlife Service and the Florida Marine Patrol to aid with injured or sick manatees. This activity has been expanded to include the collection and necropsies of dead manatees, for the respective agencies.

Twenty-four manatees have been processed since 1974. Twenty were dead on arrival. Four manatees were alive with injuries or were orphaned. The injuries varied from boat propeller cuts, to drift net and trap rope line entanglements, to gunshot wounds. The reasons for abandoned or orphaned manatees has not been determined. Twenty-two of the twenty-four manatees came from the Indian River - Merritt Island areas in Brevard County on the east coast of Florida; two were from the Ft. Myers area on the west coast.

For the most part, manatees adapt to feeding in a captive environment rather easily. If a manatee will not eat voluntarily, it can be stomach tubed with relative ease. A mixture of greens can be blended and liquified to accommodate tube feeding.

Several types of food can be fed to manatees, such as cabbage, spinach, romaine lettuce, iceberg lettuce, endive, celery, carrot tops and in some instances, fish. If an abundant supply of natural water grasses, water

lettuce/and or water hyacinths is available, they, of course, can be used.

The amount of food required for a manatee is directly related to the size of the individual. For example, a 400-500 pound animal can consume 35 to 45 kg of food per day. Food should be offered on a constant basis.

An infant manatee will nurse easily from a bottle (with an Albers Carnation lamb nipple) and seems to prefer nursing at the surface of the water.

For an infant or unweaned manatee, I suggest the following formula:

60 gm Esbilac
384 cc Neo-Mull-Soy
700 cc Water
150 cc Heavy whipping cream
177 gm Gerber's Baby Food (Egg Yolk & Cereal)
30 gm Gerber's Dry Cereal
100 gm Powdered egg white

The above mixture will make approximately 1600 gm of formula, an average daily ration. This should be fed in 4 to 5 equal parts, for an infant manatee of approximately 20 to 35 kg. This can result in a weight gain of 120 grams/day.

Formula Analysis

Moisture	76.82%
Protein	10.02%
Fat	9.10%
Ash	.11%
Carbohydrates	3.60%
Calcium	.51%
Sodium	.41%
Potassium	.17%

NURSING CARE OF STRANDLINGS.

California sea lions, <u>Zalophus californianus</u>
and a pilot whale, <u>Globicephala scammoni</u>

T. Otten
Marineland of the Pacific
Rancho Palos Verdes, California

Marineland of the Pacific each year receives approximately 100 beached marine mammmals. Of these, about 40 are California sea lions. The largest number arrives in the spring. Over 90% of these were born the previous pupping season. Most of these animals are suffering from parasitic and respiratory infections and malnutrition.

Marineland is involved in the Marine Mammal Surveillance Program in cooperation with the County of Los Angeles. The animals are picked up by local animal control agencies. They are brought to Marineland in dog and cat transport cages. Once the animal arrives, it is transferred to an open wire cage.

The first consideration is to evaluate the animal's condition. If it does not require immediate attention, it is left in the cage with fresh water available, for a few hours to acclimate to its new surroundings. Each animal is marked (by clipping hair away), with a stranding number. The Farrell system is used for identification markings. After marking, the following tests are performed: 1) blood test - CBC; 2) fecal examination; 3) respiratory evaluation.

If the animal is in very poor condition and not drinking, it is given fresh water via stomach tube. A handler removes the animal from the cage usually with the aid of a small hoop net and sits on the sea lion using his

knees to hold the flippers to the animal's side while another person passes the stomach tube. If the animal is too large for this procedure, a squeeze cage is used.

On the second day, food is offered to the animal. Fish are placed in the fresh water tray. These heavy plastic trays are 26" x 15" x 8" deep. Some animals pick the fish out of water and begin eating. If this procedure fails, small live fish can be placed into the trays; usually the animal will begin eating. If the animal is too weak to eat, it should be fed through a stomach tube. Usually herring is used because of the high caloric value. The fish is placed in a commercial blender with enough water to allow the gruel to be pumped through the tube by a small hand operated bilge pump. The 26 kg sea lion can be fed at a rate of approximately 800 ml twice daily. As the animal becomes stronger, usually within three to four days, force feeding is begun. Force feeding is also used for animals that appear to be in good physical condition upon arrival but refuse to accept fish on their own. The animal is restrained in the same manner as for passing the stomach tube. The person sitting on the animal restrains the head and opens the lower jaws by pressing his thumb and fingers into the gape of the jaw. Long blunt-nosed forceps are used to place the fish far back into the sea lion's mouth with a minimum of discomfort to the animal. After a few feedings, most sea lions begin swallowing on their own.

During the period of force feeding, the animals are housed in open wire cages placed on carts so they can easily be moved. They are kept outside during the day and moved into the laboratory at night. Once their condition has improved, they are put into either outside kennels or circular salt water pools with a haul out area provided.

Care of newborns is different from the care of the older animals. Sea lion pups will suckle up to a year of age and occasionally longer. At Marineland, we have cared for two such animals, both rejected by their mothers. They were tube fed for the first three days, using a ¼" flexible clear plastic tube fitted to a 60 cc syringe (formula on table 1). After considerable coaxing and prodding, the pups began nursing on an artificial nipple by the third day. The pups feed throughout the day, at four hour intervals. At night the security guards feed the pups as part of their rounds. The pups basically regulate their own intake but a general rule, consume 160-170 kcal./kg of body weight. The wild born pup was brought in weighing 6.6 kg, and after sixty days, weighed 13.5 kg.

On October 8, 1976, Marineland received a call about stranded whale at Long Beach, approximately 15 miles south of Marineland. The whale was an 249 cm Pacific pilot whale, Globicephala scammoni. The animal was approximately 10 months old, in good physical condition, and was believed to be a nursing calf which became separated from its mother and lost in the harbor. The young whale was placed with two older female pilot whales in hopes that the older animals would help acclimate the calf. The older pilot whales seemed to ignore the younger whale for the first few days. A stomach sample was taken from the whale and a squid beak was found so it was felt that the young whale was eating some solid food. Squid were scattered in the tank to attempt to start the young whale eating. After 12 days of fasting, the whale ate squid and some herring for 4 days, then stopped. On the fifth day, she was force fed ground squid and herring, by stomach tube. This was done with the tank drained. After three such feedings, she would open her mouth to accept the tube. The next feed was at a depth of about 1 m. of water and by the next feeding she accepted the tube

with the pool full of water. One person would swim up to her, next to the side of the tank, and pass the stomach tube while another pumped the food from outside the tank. The trainers spent a great deal of time with the young whale. Eventually, as the older whales accepted her and demanded more of her attention, less time was necessary for people to be in the water. The whale ultimately accepted the tube being placed behind its tongue, food would be pumped through the tube,and then the tube removed so that the whale could swallow. In retrospect, I would now place a latex extension at the end of the tube so the whale could collapse the tube to swallow without removing the tube. This has been done successfully with Tursiops.

The animal died from sub-meningeal hemorrhage after three months at Marineland. At that time the young whale was beginning to leap slightly out of the water while playing. It is felt that perhaps it struck its head on the side of the pool.

TABLE I

Formula:	120 cc Lactated Ringers Solution	
	240 cc Whipping Cream	
	60 cc Similac	
	20 cc Pre-digested Liquid Protein	
	1 cc Thiamine (500 mg/cc)	
	2 cc B-complex	
	550 grams Ground Herring	
	11.6 grams Nutri-cal	
Analysis:	Protein	9.4%
	Fat	18.5%
	Ash	0.8%
	Moisture	70.0%
	Calcium	0.06%
	Carbohydrate	1.3%

(by difference)
Approximately 207.3 kcal./100 grams of formula

NURSING CARE OF STRANDLINGS.

Harbor Seals, *Phoca vitulina*

C. Skinder
New England Aquarium
Boston, Ma.

One of the more common marine mammals along the New England coast is the harbor seal, *Phoca vitulina*. Every year the New England Aquarium (NEA) picks up stranded seals along the coast from Maine to Cape Cod. From 1975 to July 1977, the NEA recovered 36 live stranded seals (adults and pups), 10 of which are still alive and healthy in the seal colony.

With the exception of an occasional healthy "orphaned" pup, beached seals often arrive in poor condition. Many die within 48 hours of capture while others, showing signs of improving health, die after several weeks. In the spring, most strandlings are "orphaned" pups from breeding colonies in Maine, whereas winter strandlings are usually stunted immature animals from Cape Cod.

Harbor seals are not fragile animals though they seem to be vulnerable to eye problems and tooth breakage. Many injuries in captivity are related to handling.

Before seals are completely restrained, they usually go through a lot of twisting and turning. Their eyes are large and lack brows for protection, leaving them exposed to traumatic injuries.

Force feeding seals often requires the use of an implement to pry open their jaws. Even materials such as wood and plastic tend to break teeth and injure gums. One implement that has proven effective is heavy rubber hose.

Feeding

Pups have been reared successfully on different diets. One, a liquid formula developed at NEA, has proven to be adequate and the ingredients are easily obtainable.

Formula:	50%	Heavy cream
	50%	ESBILAC (borden's milk replacer)
	15	gm. Protein/8 oz. formula (PRO-MAGIC, powdered cottage cheese)
	250	mg. Vitamin C/day

Bottle feeding and tubing are the techniques most commonly used. Bottle feeding is more natural; it allows for feeding on demand. Unfortunately, seals often refuse to accept a bottle. Several methods that seem to induce sucking on a nipple are: wrapping the bottle in a warm, wet towel, fitting the nipple through a board covered with neoprene or consistently pushing the nipple into the animal's mouth whenever it begins to suck. A drawback to bottle feeding is weaning. Frequently,pups do not adjust to eating solid food and can be difficult to force feed.

Tube feeding is often the only recourse. Animals that learn to swallow the tube voluntarily often begin eating on demand. Tubing also has drawbacks; the tube can be placed improperly, irritation to the esophagus can result causing gag reflexes and regurgitation and if the animal is not eating on demand, over and under feeding can result. It is easier to wean a tube fed pup since it is accustomed to having its mouth opened.

Once a pup starts to eat on demand, it usually gains weight rapidly, up to 1 kg per day, until the animal reaches weaning (about 15 kg), after-which it loses 2 to 4 kg during its transition to solid food.

Many stranded animals are starving and may be too weak and disoriented to eat on their own. As a rule, the animals are tube-fed fluids on the first day, and fish is gradually added to the diet. Overfeeding is a common tendency. Excessive struggling during a feeding may be an indication that the animal is full. Getting an animal to eat on its own again is often difficult. Offering live fish or placing the animal in a competitive environment are two techniques that commonly work.

Housing

Pups are usually healthy and quarantine is not necessary. Foster homes have proven to be successful and the pups readily adapt to a bathroom tub. Frequent baths and pool swims will keep the animal clean and exercised and nearly any dry area will suffice for their frequent naps.

Stranded, unhealthy animals should be quarantined until a thorough medical assessment has been completed. The housing facility, whether a kennel or a small tank, must allow access to water, preferably a filtered salt water pool, and have a haul-out area large enough so that a heat source can be made available.

Transition to captive colonies

Harbor seals adapt well to a captive environment. Once an animal seems to be free of any infectious diseases and is eating solid foods, it is placed in the seal colony. The competition at feeding time, fresh air, clean water and exercise seem to bring the animal about both psychologically and medically.

There have never been any negative interactions between newly-introduced and established harbor seals in the NEA colony.

NURSING CARE OF STRANDLINGS.

Northern Elephant Seals, *Mirounga angustirostris*

L. Smalley and D.E. Griffin
California Marine Mammal Center
San Rafael, Ca.

The California Marine Mammal Center was founded in March 1975 for the purpose of rehabilitating marine mammal strandlings. The Center is a non-profit, volunteer operated organization, involved in public education and scientific research. Rehabilitation programs have been developed for California sea lions, harbor seals and northern fur seals, as well as northern elephant seals.

Pupping season for the northern elephant seal at Año Nuevo Island and the Farallon Islands is roughly November through January. Our "season" of acquisition of strandlings parallels this period, though we continue to receive them through July. We brought in 10 animals in 1976 and 11 in 1977. They were taken in the area bounded by the southern tip of Monterey Bay in the south, north to the Point Reyes peninsula. The overall sex ratio, determined for 17 of 21 animals, was 70.6% males. Animals less than 1 year or less comprised 81% of the total. Of 21 animals, 8 were released, 10 died, 2 were euthanized and 1 is presently being cared for at the facility.

Upon admission, the young elephant seal is first given a physical examination by a veterinarian who oversees clinical care, parasite examination, and prescribes medication as indicated.

The animal is kept quiet for the first 12 to 24 hours to allow it to become accustomed to its new surroundings, and recover from the initial handling episode. The first tube feeding consists of water with added sugar,

and formula introduced in subsequent feedings (table 1). When the animal becomes stronger we routinely worm it with levamisole hydrochloride (5 mg/lb., given subcutaneously). We also routinely dose it with 10 cc of antitoxin against Clostridium perfringens (type C & D) toxin.

Case history

Tofu, a young elephant seal pup, received routine initial care, then was tube-fed formula equivalent to 15% to 25% of his body weight, twice a day. Tofu remained on formula for three weeks after which he was given one or 2 slightly thawed herring with each tube feeding. The amount was increased as he began to swallow fish on his own. One week after introduction to whole fish, he converted to a fish diet though tubings with water and sugar continued until the transition was complete. Weight gain during this 4 wk period appeared to be less than 5 kg/wk. During week 5 and 6, Tofu ate 900 gm twice daily. This rate decreased to 1350 gm twice daily every other day just prior to release. Weight gain during this overall period was 7-9 kg/wk.

Housing

Our facility has four easily cleanable covered dog runs with good drainage, and one 3.7 m x 3.7 m x 2.4 m roofed enclosure. These are all outdoor enclosures with no heating available other than portable heaters. In addition, we have a blockhouse type building where we house very depressed and/or young animals. This building is more easily heated and the animals can be closely watched, throughout the night if necessary. Animals in this area are kept on newspaper, and the floor is disinfected two to three times a day. We have a few small wading pools in which small animals are allowed to swim. Large animals are either hosed during the day or placed

beneath sprinklers. We salt the pool water to approximately 5% concentration with no ill effects. The animals are exercised as often as possible by having them follow a person holding the fish bucket.

Handling and Tube Feeding Technique

Elephant seals can be very quick, and should be approached cautiously. They can inflict a nasty bite, even at the age of 3 months.

Our general handling technique for animals up to about 100 kg follows. Approach the animal head-on holding a piece of lightweight canvas as a shield. Lower the material over the animal covering its eyes. Restrain by applying pressure with both hands across the back of the skull and upper neck. Eventually, straddle the animals' back, applying enough weight across the shoulders to effect control of movement. The material is now allowed to fall away from the head and gloved hands are positioned with the fingers down, thumbs forward and slightly upward and palms over the temporo-mandibular joint. The head is now lifted and angled up to receive the tube. A 3.2 cm diameter hardwood dowel, with a hole in the center to accommodate the tube, is used as a bit for holding the jaw open and also protecting the tube from the animal's teeth. The distance from the bit to the stomach can be estimated by holding the tip of the tube about 10 to 12 cm cranial to the caudal border of the ribcage at the mid-lateral position and holding your other thumb at the level of the bit as a marker. A second person passes the tube to this mark and then checks that the tube is not in the trachea. This is done by blowing a short burst into the tube, then rapidly puting your ear to the tube to listen for rumbling sounds. A tube placed into the stomach has a strong odor. With the tube in place, a funnel is now attached to the free end and held high while the the formula is poured. "Milking" the tube sometimes helps the flow rate.

We have found that 1.9 cm thickwalled bevel-edged surgical tubing works well. It is rigid enough not to kink and yet flexible enough to minimize the danger of rupture of the stomach.

Table 1: Formulas

Elephant Seal Formula

1 lb Fish (generally herring or smelt)
2 tsps. salt
50 cc Cod liver oil
200 I.U. Vitamin E
200 mg Vitamin B_1
250 mg Vitamin C

Blend ingredients together.

Sugar-Water Formula

3 tbsp. Sucrose
1 liter water

Vitamins Placed in Fish

250 mg Vitamin C
200 mg Vitamin B_1
400 mg Vitamin E

Mineral supplements as available.

Acknowledgments

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MEDICAL CARE OF STRANDLINGS

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Introduction

Most single stranded marine mammals are diseased, either primarily due to parasitism, trauma or infectious agents, or secondarily following premature weaning, early abandonment, or an unsuccessful struggle against the stresses imposed by the marine environment. Such animals, many of which are already in the terminal stages of disease, must be placed into programs of intensive medical care. Success, as measured by total restoration of health, is abysmally poor in cetaceans; it is somewhat better in pinnipeds, depending on the species, age, and nature and duration of the disorder. For example, parasitic pneumonia in both phocid and otariid seals can be quite refractory to treatment, whereas storm-displaced nursing pups suffering from early malnutrition can be nursed to excellent health provided they are recovered with a reasonably short time. In this paper, we will attempt to identify the major disorders of stranded animals, and provide recommendations for therapy and

control.

Animal Enclosure

Upon arrival at the facility, pinnipeds should be placed into an enclosure that has a shallow salt water bath, a dry clean haul-out area, and fresh water available through a tap, hose or basin. The enclosure should be protected from temperature extremes and direct sun. Seals which are very thin should be held at between 15 and 25^{o}C; those that are more robust can easily tolerate colder temperatures, and should be so maintained.

Cetaceans must be placed in water, but if unable to swim, may require support in the form of a sling arrangement in which the animal is buoyant but free to breathe, or placed in a tank with only enough water to partially support the animal's weight, while lying on a foam pad.

Initial Care

Individually stranded marine mammals, unless plucked from the beach the instant they come ashore, are generally exposed to environmental extremes - exposure to sun in the summer, and cold in the winter. Excessive heat is a problem common to both cetaceans and pinnipeds that strand beyond the tempering influence of the tidal wash. Excessively low temperatures affect emaciated pinnipeds which have lost the insulating protection of blubber, and cetaceans which in northern latitudes are apt to become frostbitten.

An immediate assessment of the animal's vital signs is

required as soon as it arrives at the facility. Pinnipeds are usually alert, despite their poor condition; in fact, many are fiesty and aggressive unless truly debilitated by severe respiratory disease. By contrast, cetaceans appear to be more timid and sensitive, and are often presented in various stages of shock. These require immediate therapy upon arrival. Typically this consists of high level cortiosteriod administration, for example 2 mg/kg body weight of dexamethasone or 10 mg/kg hydrocortisone given intravenously every six hours in conjunction with high doses of supporting broad-spectrum antibiotics. If the animal thrashes uncontrollably, diazapam (Librium - Roche Laboratories, Nutley, N.J. 07110) may be administered either intravenously or intramuscularly at a dosage of 1 mg/kg body weight. Under the best circumstances, cetaceans in this condition have poor chances of recovery.

Newly arrived pinnipeds are treated essentially in the same way, though less stress is placed on intensive therapy for hypovolemic shock. On the east coast, stranded harbor seals, *Phoca vitulina*, are given cloramphenicol orally, at a dose of 20 to 25 mg/kg twice daily, and oral corticosteriods, in the form of prednisolone, at 0.8 - 1.0 mg/kg 2 or 3 times daily, or hydrocortisone, at 5 mg/kg twice daily. This steroid level is maintained for 7 days, after which it is progressively reduced and terminated by the 10th and 12th day. Antibiotic protection is maintained throughout the course of steroid therapy.

Diseases of Strandlings

Integument

In stranded cetaceans and pinnipeds, diseases of the integument consist primarily of traumatic injuries. Some, such as propellar wounds, undoubtedly contribute to the stranding event. More often, however, small shallow lacerations are sustained when an animal washes onto a rocky shore, or thrashes in mud-containing mollusc shells. Traumatic injuries can lead to infection and abscessation, especially in pinnipeds. Routine treatment is applied in these cases, while the animal is maintained preferably in sea water until recovery.

Weak stranded seals often come ashore infested with lice. On the east coast, *Echinophthirius horridis* embed particularly in the skin of the head, neck, ventral thorax and axillae of the harbor seal. Their presence in overwhelming numbers is probably secondary to nonrelated debilitating disease. The lice can be killed easily with commercially available flea, tick and louse powders containing organophosphates.

Respiratory System

Pinnipeds

Lungs and major airways are the most common sites of infection in strandlings. Bacterial pneumonia occurs regularly, probably secondary to malnutrition, trauma, parasites, and other debilitating disorders.

Bacterial pneumonia secondary to lungworm infection (*Parafilaroides decorus* in yearling and sub-adult California

sea lions and Otostrongylus circumlitus in post-weaning to yearling harbor seals) is often the cause of relatively high mortality. In addition to the pneumonia, accumulation of mucus induced by migrating larvae of P. decorus, and around adult O. circumlitus results in airway obstruction and generalized hypoxia. In harbor seals, the large adult O. circumlitus can themselves result in bronchial obstruction. In elephant seals, a worm similar to P. decorus is present, but which induces less dramatic pathology.

Therapy

Regardless of the primary cause, bacterial pneumonia in pinnipeds requires antibiotic therapy. Cultures of pharyngeal mucus, nasal exudates, trans-tracheal lavage and direct lung aspirates can yield the possible causative agent(s) from which an antibiotic sensitivity may be obtained. Generally, in pinnipeds, gram negative bacteria are involved more often than gram positive organisms. Therefore, broad spectrum antibiotics are usually more effective. No totally satisfactory anthelmintic has been found for the treatment of lungworm of pinnipeds. Levamisole phosphate (Ripercol - Am. Cyanamid, Princeton, N.J.) has larvicidal effects and may have latent effect on adult worms in sea lions. No agent has been shown effective against O. circumlitus. The obstruction sequella from the parasites has been treated with at least partial success using oral bronchodilators, e.g. aminophylline (Aminophylline, Stanlabs, Portland, Oregon 97214) at 0.5 mg/kg or mucolytics, e.g.

acetylcysteine 20% (Mucomyst[R], Meade-Johnson Labs., Evansville, Ind. 27721) and systemic bronchodilators, e.g. isoproterenol (Isuprel[R], Winthrop Labs., New York, N.Y. 10016) at 1:50,000 administered by direct intratracheal administration . Antibiotics, e.g. gentamicin (Gentocin[R], Schering Corp., Kenilworth, N.J. 07033) may be added to the intratracheal injectate.

Cetaceans

Lungworms feature prominently among the causative agents of pneumonia in only some cetacean species, notably the harbor porpoise, *Phocoena phocoena*, in which 4 species of nematodes can often be found obstructing the major airways. Few other cetaceans appear to be so infected. Cetaceans generally appear to be prone to lowered resistance, and perhaps immune-compromising states, the presence of which nearly always results in bacterial pneumonia. The condition can be suspected, with reasonable certainty, on the basis of the character of blowhole exudate, i.e. fetid odor, mucus content and cytologic examination. Pneumonia is often accompanied by general malaise, inspiratory rales (on auscultation) and increased respiratory rate. The direction of therapy relies ultimately on bacterial isolation and antibiotic sensitivity. The following antibiotics have proven effective:

gentamicin (IM)	5 mg/kg q12 hrs.
penicillin (oral)	9,000 units/kg q12hrs.
cephlexin (oral)	12.5 mg/kg q8 hrs.
chloramphenicol (oral)	22 mg/kg q12hrs.

In severe cases, combinations of antibiotics may be beneficial, i.e. gentamicin and penicillin, providing they are synergistic. Intratracheal administration requires considerable handling in cetaceans, but is efficacious. Treatment directed toward killing pulmonary nematodes (as in Phocoena) is questionable as the resulting mass of verminous emboli might well be more harmful than the presence of live worms in the major airways.

Nutritional Diseases

Nearly all stranded pinnipeds are emaciated, whereas cetaceans more often arrive somewhat thin but in good body condition. Since fat is the principal source of dietary and depot water in marine mammals, starvation quickly robs the animal of moisture, and leads to dehydration - one of the most significant clinical features in strandlings. Water replacement can be achieved quickly and assuredly through intravenous administration of a balanced saline-glucose solution. Water given through a stomach tube is quite as effective under practical conditions. A dose of 10-15 mg/kg may be given twice or three times daily for the first day or two, afterwhich fish may be blended with water to provide a coarse formula. Except in the case of nursing pups (phocid - up to 3 weeks; otariid - up to 3-6 months), the animal should be placed onto solid food as soon as possible.

Starvation in marine mammals is a rather non-definable state in which the animal suffers from a variety of nutrient deficiencies. It is beneficial to institute a course of vitamin

replacement as soon as possible. Vitamin powder (from capsules if necessary) may be given with the first tubing of water. Any commercial preparation containing the water soluble vitamins, given at twice the recommended human or animal dose for the first few days will ensure adequate replacement. Thereafter, the animal's vitamin schedule can be maintained as in any other member of the colony. Virtually all other nutrients including minerals and oil soluble vitamins can be supplied simply by providing good quality <u>whole</u> fish, either by forced or voluntary feeding by hand, or as a gruel. Involuntary feedings should not exceed 3-4% of body weight divided over 3 feedings per day for the first week, then increased to 4-7% of body weight. Except in rare instances, animals not eating voluntarily after 2 to 3 weeks are a poor risk, and an unmerited drain on most husbandry programs.

Occasionally newly arrived starving pinnipeds may exhibit an involuntary "tic " which leads progressively into tonic-clonic convulsions. Such animals are often hypoglycemic and respond almost immediately either to glucose or corticosteroids administered intravenously. Experimentally, if glucagon is administered, there is no responsive rise in blood glucose indicating an absence of liver glycogen in these animals. Functionally, therefore, all carbohydrates for metabolism must come from exogeneous sources. Therapeutic measures consist of providing glucose intravenously and in a subcutaneous depot, tube feeding a fish gruel with added glucose, and injected corticosteroids

to reduce glucose utilization. The therapy is repeated every four hours providing there is peristaltic activity.

Gastrointestinal Diseases

Stranded pinnipeds are often heavily infested with gastrointestinal parasites, particularly a wide variety of gastric nematodes. The worms are not necessarily harmful, but can be associated with ulcers. Weak, starving pups sometimes vomit live worms or worm fragments. Diagnoses can be made by observing ova on fecal smears. Nematodes can be found in stranded cetaceans as well, but not nearly in the same numbers as in pinnipeds.

Tapeworms are common to both pinnipeds and cetaceans. A heavy infection, particularly in weak seal pups, can be associated with malaise and diarrhea. Affected animals usually shed long ribbon-like fragments with the feces. Otherwise, diagnosis depends on identifying operculated eggs in the feces.

Stranded harbor seal pups have been found suffering from necrotic ulcerative stomatitis and gingivitis. The teeth can often be pulled easily from eroding alveoli. The cause of the condition is unknown; it may have a nutritional basis. The disorder appears to be quite painful as affected pups refuse food voluntarily and resist attempts at being force-fed. Euthanasia seems to be the most humane solution to this problem.

Gastric ulcers are a common finding in stranded pinnipeds and cetaceans. The cause is not well understood, but parasites and stress may play a role. The condition is associated with

malaise, inappetance or irregular food intake, and abdominal tenderness. Shallow ulcers may eventually erode into the submucosa resulting in the presence of blood cells within the gastric contents - a diagnostic feature. Perforation is not uncommon.

Ulcerative enteritis, the etiology of which is similarly unknown but possibly relates to stress, occurs with some frequency in the California sea lion. Signs are similar to those of gastric ulcers, but include profuse diarrhea which may contain white blood cells - again a diagnostic feature.

Trematode - induced bile and pancreatic duct occlusion and fibrosis are common findings in certain stranded species. Nearly every stranded adult harbor porpoise along the east coast has related damage caused by Campula oblonga which affects the pancreas more than the liver; in extreme cases the pancreas is reduced to a solid knot of fibrous tissue. The condition scarcely seems compatible with a healthy life, and may well play a role in natural mortality and strandings.

Similarly, in California sea lions, cholecystitis is a frequent finding resulting from obstructive aggregations of liver flukes, Zalophotrema hepaticum. These cause bile duct dilation and thickening, with secondary obstructive hepatitis. The operculated ova can be found in the feces, and this, along with elevated serum transaminase and bilirubin, confirms the diagnosis. Clinical signs include malaise, with jaundice in extreme cases.

Therapy

Gastric nematodes can be removed safely using piperazine compounds, administered at the rate of 50-75 mg/kg of body weight. With time, captive pinnipeds shed the worms within 2-3 weeks, without the aid of anthelmintics. For treatment against tapeworms, neclosamide (Yomesan; Chemagro Corp.) is effective at a dosage rate of 80-110 mg/kg of body weight. Treatment may be repeated as required. No agent has been used against C. oblonga in porpoises, and no agent has yet been shown to be effective against Z. hepaticum in sea lions.

Gastric ulcers can be treated with oral antacid compounds and anticholinergic drugs, for example cimetadine (Tagamet - Smith, Kline Corp. Carolina, PA).

Special Senses

Keratoconjunctivitis is sometimes found in stranded pinnipeds and cetaceans. It is characterized by blepharospasm and a mucopurulent discharge. The inciting cause may be trauma, but the condition nearly always becomes complicated by bacterial infection.

Parasite-induced encephalomalacia is the most frequent cause of cetacean single strandings along the Pacific coast, notably in Delphinus delphis and Lagenorhynchus obliquidens. The organism, believed to be the trematode Nasitrema sp., burrows into the cerebrum and cerebellum, resulting in necrosis. Affected animals show loss of equilibrium and are unable to swim. The organism

is also found in the pterygoid sinuses from which they release ova into the blowhole exudate. The condition has been found in only one of the rare D. delphis specimens which has been examined along the New England coast during the past 5 years.

Other parasites are associated with neurosensory organs, but with no evidence of associated disease. This is true of Stenurus sp. the small nematode which fills the cranial sinuses and middle ears of a number of odontocete species, and which has been implicated, as yet with no evidence, in strandings.

Therapy

Keratoconjunctivitis can be treated with standard topical ointments in pinnipeds. It is more difficult in cetaceans which clamp their eyelids shut at the slightest provocation. In either case, it may be necessary to squirt aqueous medications onto the eye using a syringe and needle, or administer systemic medications which can pass through blood-aqueous barrier, i.e., chloramphenicol. At all costs, avoid excessive tampering with the eye. Good intentions often result in perforation especially in pinnipeds that are difficult to restrain.

Verminous encephalomalacia and stenurosis are non-correctable diseases at the present time. It is doubtful whether treatment would be effective in the case of the former, or even indicated in the case of the latter.

Cardiovascular

The only known cardiovascular disease of clinical importance

is heartworm infection in harbor seals. The organism, Dipetalonema spirocauda, is found in the right ventricle and pulmonary arteries. The clinical signs are non-specific, and the diagnosis is based on finding microfilaria on peripheral blood smears. In a recent survey of 85 stranded harbor seals along the New England coast, 56% of males and 39% of females had heartworms. We have ambivalent feelings toward treating this condition. In seals not clinically affected by respiratory-cardiovascular disease, treating for heartworms may only tend to complicate matters through consequent verminous emboli. Those animals in which heartworm is responsible for clinical signs would doubtfully survive even a single dosing with filaricides for the same reason. If indicated, filaricides aimed toward killing intravascular adult worms can be administered, i.e., thiacetarsamide (Caparsolate, Diamond Labs.) intravenously at a dosage of 0.02 mg/kg body weight, once or twice daily for two days.

Urogenital

Vaginal lacerations and pyometra in adult female pinnipeds occur as a result of parturient or post-parturient trauma. The lesions are usually chronic and exhibit cellulitis with occasional recto-vaginal fistulas. The diagnosis is made upon physical examination.

Renal calculi are found commonly in elephant seals of all ages, less frequently so in harbor seals, and occasionally in sea lions. They are also found occasionally in cetaceans. The stones are usually mixed triple phosphate and uric acid. These

are often incidental findings at necropsy.

Therapy

Therapy for vaginal laceration is limited to surgical debridement. Since the lesions are usually grossly contaminated with feces and soil, therapy for anaerobic bacteria may be beneficial. Clindamycin HCl has been used for this purpose. Cases with pyometra require hysterectomy.

No therapy has been proven successful for renal calculi, in part because the condition is rarely diagnosed and the response to therapy is difficult to measure.

Infectious Diseases

Leptospirosis has been found in stranded California sea lions. The disease is subadult and adult animals is associated with malaise and hind limb stiffness. Clinical pathological findings are related to nephritis and include elevated serum titers for *L. pomona*.

Although seal pox is a viral disease encountered most frequently in young pinnipeds a month or two following capture from the wild, it appears occasionally in stranded individuals. The cutaneous lesions are round (0.5 - 1.5 cm in diameter) and elevated (up to 1 cm) and exhibit hair loss and superficial necrosis at the surface. The lesions can appear within several days and have a predilection for the head and neck regions. The disease may spread from animal to animal but rarely occurs in resident, acclimated individuals. It is, therefore, thought

to be stress mediated.

Miscellaneous Conditions

A wide variety of microbial parasitic and neoplastic diseases have been described in strandlings. Some are of sporadic occurrence and are merely incidental findings. Others, such as gastric mucosal infection by the trematode *Braunina cordiformis* in *T. truncatus* and parasitic mastitis caused by *Crassicauda grampicola* in *L. acutus*, as well as neoplasms and cardiovascular disease, occur with predictable certainty in select species within a definable geographic area. Most of these conditions have not been dealt with in detail because they are, for all practical purposes, non-treatable. Their importance lies more in helping us define disease conditions which play a role in life history of marine mammals at sea.

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THE REHABILITATION OF SEA OTTERS

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For the past several years, the California Department of Fish and Game and Sea World, Inc. have been active in the recovery and rehabilitation of stranded California sea otters (*Enhydra lutris*). Although at one time thought to be extinct, the California population of sea otters has made a substantial comeback over the years and now current estimates based on recent surveys indicate the population to be approximately 1,850 ± 4% (Dan Miller 1976, pers. comm.). They currently occupy an expanding range of about 260 km of the central California coastline.

Most field researchers generally agree upon the conditions and causes associated with sea otter mortalities (Kenyon 1969, Estes and Smith 1973), Wild and Ames 1974, Morejohn, Ames and Lewis 1975). The number of dead and moribund animals found on the beaches usually increases during the stormy periods of late winter and early spring. Proximity to human population centers, ease of coastal access, and general public awareness also influence the recovery of sea otters (Wild and Ames 1974).

Kenyon (1969) noted that healthy adults spend less time on shore (as indicated by animals captured there) during periods of storm surf than do emaciated juveniles and old adults. Most dead sea otters are found on or near favored hauling-out or resting areas (Estes amd Smith 1973).

Kenyon (1969) has divided causes of sea otter mortalities into two groups. The first group consists of those whose death was caused by injury

or disease, the second group consists of those which showed evidence of starvation and exhibited symptoms of enteritis. Our recent experience pinpoints 3 major causes, exhaustion and exposure associated with emaciation and enteritis, primary disease, and orphaning. The first category seems to affect dependent juveniles and aged adults. Primary disease can affect animals of all ages. Kenyon (1969) and Estes and Smith (1973) found that immature animals comprise 66 to 70% of the annual mortality in Alaska. Wild and Ames (1974) in California have discovered a large number of subadults and pups during certain periods of annual die off. Our experience parallels their findings. Four of the five sea otters we have received to date have stranded after severe storms during the late winter/early spring period.

Handling

Small animals can generally be picked up with little or no danger to the animal or to the person making the recovery. Larger animals, however, are potentially dangerous. Though they may appear to be lethargic or almost comatose, they can inflict serious bites. Small-to-medium-sized dog transport cages or similar units have been successfully used in the past to hold and transport these animals. We custom-build transport units for the movement of larger animals. These units consist of a watertight fiberglassed wooden bottom and nylon net-covered upper wooden framework. This construction allows the animals to be transported in 10-15 cm of water while providing for adequate ventilation. The approximate dimensions of the unit are 90 cm long x 60 cm wide x 60 cm high.

Transport to a treatment center should be rapid, and attention should be given to the animal's vital signs. Light aircraft have been used in

transporting stranded sea otters to treatment centers. These animals are susceptible to heat stress and provisions must be made to keep them cool but not overchilled. In the past we have used buckets of water for occasional immersion of small pups, and water sprayers and ice cubes to help keep larger animals cool. Signs of heat stress in sea otters are fairly obvious: mouth breathing, the extension of limbs, general lethargy, and occasional moaning or vocalization. The normal rectal temperature of a California sea otter is about 37°C. Primary sites of otter thermoregulation are the fore- and hindlimbs, which can be used to subjectively monitor body temperature.

During transport, steps should be taken to keep the animal as free from fecal contamination as is possible. Soiling of the pelage results in matting and loss of the fur's insulating properties.

Upon arrival, the animal should be given a thorough physical examination and a blood sample taken. Small volumes of blood may be obtained from toenail clips; adequate venous samples are taken from the caudal vein, the femoral vein, or the inferior vena cava. Stool samples should be examined frequently for parasites and enteritis.

The holding facility should have a pool with clean unchlorinated salt water, adequate haul-out area, and in instances where chilling may have occurred, access to either a heat lamp or a space heater. We have found it advantageous under certain conditions to place a stranded sea otter with our resident population of otters.

Due to their high metabolic rate it is important to feed emaciated sea otters as soon as possible. Some items that are currently used include clams, squid, abalone trimmings, crabs, sea urchins and shrimp. It is imperative that hard-shelled items remain in the otter's diet to act as

roughage, which helps to control enteritis.

Neonate otters are initially fed a formula consisting of whipping cream or half-and-half and a mixture of ground fish or clams, fortified with vitamin and mineral supplements. However, the animals show better weight gain and improvement in overall body condition when fed solid food.

Kenyon (1969) has noted that a fasting or sick animal may lose up to 10% of his body weight daily. Weight losses approaching 25% are serious. Feeding intervals should be frequent, up to five times a day for adults, and up to seven times a day for pups. In addition, an excess of food items should be left for the animals to graze on between regularly scheduled feedings. It is desirable to weigh animals as often as two or three times a week.

Case Histories

Case No. 1: In March of 1976, after a severe storm off Monterey, a 2.7 kg female sea otter pup was recovered by the California Department of Fish and Game. After several unsuccessful attempts to locate its mother, the pup was flown to Sea World in San Diego. The animal was malnourished and anemic but in otherwise stable condition. Within an hour after arrival she readily ate small bits of clams, shrimp and squid. For the first two months, she was attended 24 hours a day and fed on demand. This usually constituted 10-12 feedings per day. She consumed approximately 25-30% of her body weight daily and received supplemental liquid vitamins and hematinics. On this diet she exhibited a weight gain of 7.2 kg in 6.5 months.

During the first several weeks the pup was housed in an open top plastic container lined with towels located inside an enclosed but unheated

utility room. The animal was rinsed off in a salt water pool to clean contaminants from the fur coat and soiled towels were replaced. As she grew and became stronger, periods in the pool were extended so that she learned to swim and dive with some expertise. After a month, she was moved to an outside enclosure.

Two problems observed soon after arrival contributed to her death. She was parasitized by acanthocephalan worms, which are common in California sea otters (Morejohn, Ames and Lewis 1975); treatments were ineffective. Her second problem involved lack of proper grooming. Chlorinated water tended to remove the natural oils from the fur. As a result, her coat became badly matted and lost much of its insulating quality. Attempts by attendants to brush and groom her fur were ineffective. In time, she developed hemorrhagic enteritis and anemia, and died of secondary acute pneumonia.

Case No. 2: A 19 kg adult male sea otter was picked up in October 1976 in Morro Bay, California, by the California Department of Fish and Game. The animal became heat stressed during transport, and on arrival was immediately placed in a salt water pool, where it apparently recovered quickly. His behavior was depressed and he showed little interest in food. During the first two weeks, the animal was fed on demand. The animal's consumption of mollusks and crustaceans improved but was never considered excellent. Two days before he died, the animal readily ate anchovies along with his regular fare.

From the outset, the animal exhibited a progressively more obvious "shivering" of the head and forelimbs, and had limited movement of his rear legs. While in the water his grooming was typical; however, the

animal needed assistance to exit from the pool and, once out of the pool, did not move around the enclosure. Blood values were normal. Treatment included steroids, antibiotics and diphenylhydantoin. In the last days before his death, the tic grew markedly worse. The animal's behavior was stereotyped, much like a Parkinsonian incoordination, and brain lesions were suspected. Necropsy disclosed medullary hemorrhage, and systemic coccidioidomycosis.

Cases Nos. 3, 4, and 5: In March 1977, we received three strandlings, one adult female and two pups (one male and one female). The nearly comatose adult female had pneumonia and a kidney infection. She was placed into a nonchlorinated salt water pool; fluid therapy as well as oral antibiotics were administered. At the end of seven days, she showed remarkable improvement and was moved into our large sea otter pool with the resident animals, where her activity and appetite picked up substantially. Within a matter of a few weeks she had gained 3.6 kg. After four months, she had no further clinical signs; she was released at St. Lobos after cryogenic marking and a flipper tagging.

The female pup had difficulty eating and swallowing. She was fed both formula and small bits of solid food, but would often vomit during and after feeding. Attempts were made to feed the animal via stomach tube, but again vomiting frequently occurred. After three weeks the pup died and a necropsy disclosed megaesophagus, enteritis, and agonal asipration of vomitus.

The male pup was also fed formula and small portions of solid food items. This male was only about two weeks old upon arrival. He was parasite free, and exhibited vigorous grooming behavior. His growth rate

was remarkable; body weight increased from 2 kg to 10.2 kg and body length from approximately 50 cm to 95 cm in 5 months. He has intermittently been exposed to the adult sea otters in Sea World's resident pool and the interaction seems to stimulate his activity and appeptite.

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Abstract

THE QUANDARY OF WHETHER TO RETAIN OR RELEASE REHABILITATED STRANDLINGS

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Due to improved husbandry techniques and a better understanding of diseases and medical treatment, a larger percentage of stranded marine mammals, especially pinnipeds, is being salvaged. This presents the problem of whether to retain or release such animals. Some argue that the rehabilitated animals should be released. Others express the view that strandlings should be distributed to public display and scientific research institutions, thereby replacing others that might be taken from wild stocks.

Ultimately a sound release program must be established. At present, however, there is not enough information available on which to base a successful release program. Such a program must include marking the released animals and follow-up observation to get some idea of survivorship patterns.

Greater effort should be made to place rehabilitated strandlings in oceanariums, zoos and research institutions that have needs for animals. A register of rehabilitated strandlings should be maintained for this purpose. It is expected that these animals will have a higher mortality

rate than healthy wild caught individuals, and this should be taken into consideration by the regulatory agencies. Sale of these animals will help defray the costs of care and treatment borne by the rehabilitating institutions. This should encourage greater effort in the salvaging of strandlings.

We estimate that rehabilitated strandlings of Phoca vitulina, Zalophus californianus and Mirounga angustirostris could meet all the requirements for public display of these species within the next few years. Meanwhile, research should be pursued and pilot release programs with sound biological bases should be initiated.

REGIONAL STRANDING

NETWORKS

A DEVELOPING NEW ENGLAND MARINE MAMMAL STRANDING NETWORK[1]

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Since enactment of the Marine Mammal Protection Act in 1972, public interest and awareness of marine mammals has increased. From the standpoint of regulatory agencies and the scientific community, this is reflected by prompt reporting of strandings and beachings, more frequent sightings, and demand for action.

In order to respond and optimize the scientific potential of a stranding, a network of interested individuals and institutions has been established in New England. The concept of a coordinated network involving interested lay persons, conservationists, researchers, and government agencies arose as a result of two stranding events. In 1973 and 1974, two strandings of Atlantic white-sided dolphins (*Lagenorhynchus acutus*) provided a unique opportunity to study the pathobiology and life history of this relatively unknown species. It was apparent after the second stranding that the full research potential could not be realized with the personnel and resources of the New England Aquarium (NEA).

In addition, it became apparent that a more formal and organized system was needed to respond to reports and pick up specimens. Letters offering material were sent to marine mammal scientists throughout North America to initiate an interdisciplinary research program, and plans were made to effectively utilize public interest in marine mammals.

[1]Supported by the Marine Mammal Commission, Contract No. MM6-AC015.

The New England network includes personnel of the National Marine Fisheries Service, Fish and Wildlife Service, National Park Service, and the local State Department of Fish and Game or Natural Resources to coordinate jurisdictional responsibility as well as the local police and conservation officers from coastal cities and towns. In addition to the NEA, other local aquariums have established response teams or provided rehabilitation facilities for live animals. The U.S. Coast Guard is an active participant, providing communication and transportation support. The research team consists of forty-three individuals.

Communication is maintained within the network by regional meetings, special posters, mailings, and summaries of the program (Appendix I).

The network can be divided into six operational functions: observation, notification of stranding, response, reporting to jurisdictional authorities, coordination of scientific activities, and recording.

Observations are usually made by individuals on the scene at the time of or shortly after the event. These people frequently report the occurrence to the local police, federal wildlife agencies, or, in the case of live beaching, one of the local aquariums. Requests for assistance and information about the stranding program have been forwarded to local, state, and federal agencies. Posters and the public media have been utilized to inform the public.

Notification of the stranding is processed by the recipient and the information is forwarded to the nearest participating organization. Nearby organizations with special interests in the species involved are also alerted. Twenty-four hour answering service is required for this function.

The response includes immediate telephone advice and the dispatch of a field team to rescue live animals, salvage dead carcasses, perform field

necropsy, or arrange transportation to an appropriate institution. The response team may be dispatched to the scene before notification of the local enforcement agency

Reporting the event to law enforcement agencies is the responsibility of the organization responding,not the individual reporting the stranding. This is done to relieve interested individuals of legal responsibility and to ensure that proper legal action has been taken.

Coordination of scientific activity was done in the early stages of establishing stranding research programs in the New England region. Principal scientists were recruited, who could address various aspects of a stranding. Using this team, all stranded animals are examined; those which are dead are measured and necropsied. Tissues are distributed to research participants and many are banked for future analysis. Live animals are medically examined, and released or placed into nursing and rehabilitation programs.

Recording includes notifying the Smithsonian Institution, and forwarding reports on necropsies, health examinations and disposition to the National Marine Fisheries Service and state agencies.

The New England network has encountered problems. There have been times when it was difficult to establish priorities in qualified research programs, and to resolve the problem of conflicting requests. A program that began with a few animals now examines over 150 individual strandees per year. This increase has affected the logistic support and the timeliness of reports. These weaknesses should not be considered a major pitfall. They can and have been resolved without compromising the effectiveness of the stranding program.

Costs

The costs for the New England stranding program can be classified as fixed and variable. Fixed costs include such items as staff, facilities, and permanent equipment and supplies. Variable costs are those expenses incurred as the result of a stranding and include labor for the field response team, transportation of specimens and personnel, and medical expenses. Based on our experience, an average cost of fifty dollars ($50.00) per animal has been incurred for the initial response phase for individual small cetacean and pinniped strandings. Large whales can significantly increase these costs, and mass strandings can lower the average figures; all are dependent on the location and remoteness of the event.

Research program costs have not been included due to the extreme variation between such diverse efforts and facilities required for studies ranging from taxonomy to measurement of environmental pollutants.

APPENDIX I

PROCEDURES FOR RESCUE, RECOVERY AND IDENTIFICATION OF STRANDED MARINE MAMMALS

Whales, dolphins and seals often become "stranded" on the beach when they are critically ill or injured. This information has been prepared to guide your efforts when one of these marine mammals washes ashore.

I) Action to be Taken

The Marine Mammal Act of 1972 prohibits, without approval from Federal State and local authorities, the "taking" of any marine mammal by a U.S. citizen anywhere in the world. The definition of "take" as cited in the "Marine Mammal Act of 1972" includes; to harass, hunt, capture, collect or kill, any marine mammal including without limitation, any of the following: the collection of dead animals, or the parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; or the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional acts which result in the disturbing or molesting of a marine mammal.

A) Live Animals

Upon finding a live marine mammal, call the NEA immediately. In addition to answering questions, assistance will be provided. Most live animals require immediate attention and the following action should be taken.

Upon finding a live whale or dolphin near the water, try to return it to the sea.

If a whale or dolphin is beached, the most important thing to do is to keep it cool, moist and shielded from direct sunlight. This can be accomplished by draping the animal's body with wet clothing, towels or blankets. Someone should stay with the animal to keep gulls away and prevent the wave and surf action from drowning or washing the animal away. Dolphins should be supported or made comfortable and rolled from side to side every 20-30 minutes to aid its breathing and prevent pneumonia.

Whales are usually too large to move but they should be kept wet and protected from gulls.

Adult seals often require nets and cages to be used for rescue and capture. Caution should be exercised and keep away from the mouth. They are quick and can bite.

Once caught, the best treatment is to place them in a dark quiet and cool area and be left alone until additional help arrives.

Pups are easier to handle and can be kept temporarily in a tub or box enclosure. There is no need to give water or feed the animal during the first 24 hours. No cows milk should be given to seals, they cannot digest the milk sugar, lactose.

B) Dead Animals

Dead animals are equally important and valuable research information can be obtained from the carcasses. If possible, small seals, dolphins and porpoises should be moved, covered and kept cool. This is especially important during the warm summer months for decay occurs more rapidly during this time. Place the smaller animals in a plastic bag and, if possible, put the animal in a cold area or freezer.

Whales, however, are too large to be moved. Try to identify and describe the animal and call state or local authorities, or the New England Aquarium. A special crew will be dispatched to perform an autopsy on the beach.

NOTE: Since some of these animals will be sick and the dead ones decaying, be sure to wash thoroughly after touching any marine mammals. If bitten, contact your doctor immediately.

C) Things to Determine Before Calling

Before notifying the proper authorities, please attempt to determine the following information:

1) Identification or description of the animal.
2) Number and condition of the animals.
3) Location and accessibility.
4) Details of the stranding.
5) Names and telephone numbers of people involved.

II) Contact Numbers

Appropriate places to call in the event of a marine mammal stranding:

A) New England Aquarium (NEA). (617) 742-8834

B) Scientific Event Alert Network (SEAN). Smithsonian Institution (202) 381-4174.

If you wish to call SEAN collect, please call the following number: (202) 628-4422. Collect calls may be made to this number from 0900-1700 (9 AM to 5 PM) local time (1400-2200 GMT) Monday through Friday.

C) National Marine Fisheries Service (NMFS).

Gloucester, Mass.	(617) 281-3600
Provincetown, Mass.	(617) 487-9377
New Bedford, Mass.	(617) 992-7711
Portland, Maine	(207) 773-9803
Rockland, Maine	(207) 594-7742
Pt. Judith, R.I.	(401) 789-3320
Newport, R.I.	(401) 849-5029
Jamaica, N.Y.	(212) 995-3410
Patchoque, (L.I.) N.Y.	(516) 475-8454

D) United States Coast Guard (USCG)

Call the number listed on the cover of the telephone book with listings for your local area.

III) Basic Identification

The New England region distributes to any interested party an illustrated list identifying each animal likely to strand within the region. Three examples follow:

A) Seals (Order Pinnepedia).

Harbor Seal (*Phoca vitulina*)

a) Fur present, the color ranging from light grey or tan to brown and red, with irregular spots.

b) Approximate length of adult males is 6 feet, females - 5 feet.

c) Catshaped head with a concave forehead.

B) Baleen Whales (Order Mysticeti)

1) Fin Whale (*Balaenoptera physalus*)

a) Average length is approximately 70 feet.

b) Slender body with very prominent, triangular shaped dorsal fin.

c) Back is grey in color while undersides, lower side of flukes and flippers are white.

C) Toothed Whales (Order Odontoceti)

Common Dolphin (Delphinus delphis)

a) Average length is 6.8 feet.

b) Back is darkly pigmented, belly is white.

c) Characteristic "crisscross" pattern of light grey or ochre running along sides.

d) Body is slender with a narrow pronounced beak, separated from the forehead by a groove.

e) White streak extends across the melon, a thin "black mask" encloses the eyes, and a black band runs from chin to front edge of flipper.

PROPOSAL FOR A NORTHEAST NETWORK

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New England Aquarium
Boston, Massachusette 02110

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Bar Harbor, Maine

W. Medway
University of Pennsylvania
School of Veterinary Medicine
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H.E. Winn and J.L. Dunn
University of Rhode Island
Kingston, R.I. 02881

R. Whittaker
National Marine Fisheries Service
Gloucester, Massachusetts

J.G. Mead
Smithsonian Institution
Washington, D.C. 20560

A northeast regional stranding network is proposed which will incorporate the New England network and include the coastal zone from Maine to Delaware. Expansion beyond New England is desirable because of a current gap in the mid-Atlantic region, between the current New England network and the Smithsonian Institution in Washington, D.C. The geographic boundaries of the proposed network are identical with the National Marine Fisheries Service's northeast region.

In 1976, more than 130 specimens stranded in the region. These included 2 pinniped, 9 toothed whale and four baleen whale species. The network will establish a cooperative program between private and public agencies, including the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the U.S. Coast Guard, the Smithsonian Institution, state agencies, such as Fish and Game Departments, or Departments of Natural Resources, and private or academic institutions such as the College of the Atlantic, the University of New Hampshire, the University of

Massachusetts, the Woods Hole Oceanographic Institution, the University of Rhode Island, the University of Delaware, the New England Aquarium, Sealand of Cape Cod, the Mystic Marine Life Aquarium, and the New York Aquarium.

The plan includes a statement of priorities regarding animal and public welfare, research objectives and a determination of responsibility to resolve legal, jurisdictional and disposal problems for the eight state region. To ensure that all stranding opportunities are realized, a communication network will be established which will also provide for efficient coordination of resources, including appropriate response teams, distribution of research materials and the accumulation of shared data and record keeping for research programs. Shared data will be developed as part of a central data system model currently being evaluated in the National Marine Fisheries Service's regional center in Gloucester. Included in the plan are cost estimates for the program and a suggested mechanism for the distribution of funds in a responsive manner.

PROPOSAL FOR THE ESTABLISHMENT OF A SOUTHEASTERN UNITED STATES REGIONAL MARINE MAMMAL STRANDING NETWORK

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Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, Florida 33149

with the assistance of the
marine mammalogists in the southeastern United States

The southeastern network will encompass the same area as the National Marine Fisheries Service Southeast Region, that is those coastal states from, and including, North Carolina through Texas, plus Puerto Rico and the U.S. Participation in the network is open to all.

In order to be successful, the network must have a functional communication system on a local and regional basis. The NMFS Southeast Region Law Enforcement office in St. Petersburg, Florida will undertake this function. A communication system already exists between this office and its various agents throughout the region. The region office will also serve to coordinate efforts with the various state agencies that enforce the Marine Mammal Protection Act. The region communication center would be advised of all strandings. In the event of mass strandings, the center would notify additional field and laboratory workers.

The Region has been subdivided into a number of field and laboratory units, based on investigators and institutions currently working with stranded marine mammals. Organizations capable of holding live animals are indicated (*). A breakdown of the regional scheme follows:

North Carolina	J.G. Mead, Smithsonian Institution
South Carolina	A. Saunders, Charleston Museum
Georgia	H. Neuhauser, Georgia Conservancy
Florida	
northeast	D.K. Caldwell, University of Florida, Whitney Marine Laboratory, Marineland*
east central & N.W. central	E.D. Asper, Sea World*
southeast and southwest including Keys	D.K. Odell, University of Miami Marine Laboratory
	J.E. White, Miami Seaquarium*
	Ocean World*
west central	R.T. Goldston, Sun Coast Marine Mammal Foundation*
Panhandle	
eastern	Florida State University Marine Lab(?)
central and west	B. Siebenaler, Gulfarium, Ft. Walton Beach*
Alabama	University of West Florida (?)
Mississippi	D. Jacobs, Biloxi, Mississippi Marine Animal Productions, Gulf Port* (?)
Louisiana	G. Lowery, Louisiana State University, Museum of Natural History
Texas	D. Schmidley, Texas A & M University
	Searama, Galveston* (?)
Puerto Rico & Virgin Islands	(?)
Lab Units:	
Pathology	
Florida	J. Popp, J.C. Woodard, and R. Schimpff University of Florida
Texas	D. Cowan, University of Texas Medical School, Houston
Parasitology	D. Forrester, University of Florida

A sirenian salvage network was established in 1974 by H.W.Campbell, National Fish and Wildlife Laboratory, Gainesville, Florida, and consists primarily of 2 field units: the NFWL and University of Miami Marine Lab (Odell). Communication is through a number of local contacts and the Florida Marine Patrol. The establishment of a cetacean network would likely benefit the sirenian network. A combination of the two networks is a possibility but has not yet been discussed.

Scientific Coordination

A "scientific coordinator" will be designated within the Region (currently D.K. Odell). This person would handle scientific communication within the region, encourage maximum utilization of all stranded animals, and refer requests for material from people not directly involved with the network.

Financing

In some parts of the Region, animals will continue to be salvaged irrespective of funding. In other areas salvage cannot take place unless funded. An estimation of the cost of running the network cannot be given until existing resources have been assessed.

Progress

A number of people from the southeast region who were present at the Stranding Workshop met to take the initial steps toward organizing the regional network. The following were undertaken:

1) Preparation of a Regional Directory - C. FUSS
2) Assessment of live animal handling resources - E.D. ASPER
3) Assessment of field and lab unit resources and capabilities - A. SAUNDERS

Upon completion of the directory, a simple data sheet listing minimum required data for each stranding will be distributed throughout the region. Completed data sheets will be forwarded to the scientific coordinator for verification of completeness, and then to the Communications Office for encoding and storage in a word processing device. Monthly printouts will be distributed throughout the region and to SEAN (the Smithsonian's Scientific Event Alert Network).

PROPOSAL FOR A WEST INDIES NETWORK

H.E. Winn
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University of Rhode Island
Kingston, RI. 02881

and

E.L. Towle
Island Resources Foundation
St. Thomas
U.S. Virgin Islands, 00801

A stranding alert network in the West Indies, including Puerto Rico and the Virgin Islands, would broaden the geographic coverage with respect to southerly ranging cetaceans. Briefly, the best organization to coordinate such an effort throughout the West Indies would be the Island Resources Foundation. Each biological laboratory from Puerto Rico to Barbados (or Venezuela) would be an integral part of the system. Newspaper publicity and notices in all major marinas would be important. One of the Foundation's staff members would be trained to obtain information. All material and information would be forwarded to the Smithsonian Institution. A small budget including salary, supplies and travel could be reasonably effective. A list of the laboratories that would be part of the system will be discussed.

PROPOSAL FOR A CALIFORNIA NETWORK

E.T. Nitta
National Marine Fisheries Service
Terminal Island, California

The problem of stranded and beached marine mammals has become an issue of major concern to the Federal, State, and local agencies involved. With the protection of marine mammal stocks, the reported incidence of beached animals has increased dramatically.

The California sea lion, northern elephant seal, harbor seal, and the grey whale are protected by one or more Federal statutes, which in some cases complicates their retrieval or rehabilitation. Recovery of carcasses and live stranders is accomplished under Section 109 of the Marine Mammal Protection Act and Section 216.22 of the regulations of the California Department of Fish and Game (CFG).

Under the present system, the local CFG marine warden is usually the first to receive notification of a stranding. If the animal is alive it is turned over to a State authorized rehabilitation center. Carcasses are turned over to scientific investigation.

The National Marine Fisheries Service, Southwest Region's policy has been to consider endangered marine mammals simply as marine mammals once they are stranded on the beach. This policy allows the State to make such animals available for scientific study, or legally dispose of the remains.

The proposed California network consists of the California Department of Fish and Game, their authorized rehabilitation centers, qualified

educational and scientific research institutions, organizations and individuals, and the National Marine Fisheries Service Southwest Region. The network will be coordinated at the local level by the CFG warden on the scene. Each warden will have an area list of potential cooperators and their interests (i.e. live animals, dead animals, pinnipeds, cetaceans, tissue samples, morphology, etc.) The warden will determine the disposition of the animal(s), whether for research, rehabilitation or disposal. NMFS and the CFG field supervisors will resolve any on-site questions.

The basic reporting requirements will include the type of data taken (i.e., measurements, tissue samples etc.) final disposition of the skeletal material, soft parts, and hide, and date and location of acquisition. The State will continue to submit monthly stranding reports to the Southwest Region under existing arrangements.

PROPOSAL FOR A PACIFIC BASIN NETWORK FOR RETRIEVING STRANDED MARINE MAMMALS

E.W. Shallenberger
Sea Life Park
Hawaii

Introduction

The Pacific Basin is a vast area rich in marine mammals and relatively unstudied. Each year there are numerous strandings, only a few of which ever reach the scientific world. Much of the Pacific Basin is under United States control and it is feasible to recover strandings from these islands. The major ones are the Hawaiian Islands, consisting of the eight major islands and the numerous small atolls and pinnacles of the Leeward Chain. The total Archipelago stretches more than 1500 miles and is made up of 132 islands, reefs and shoals. The rest of the Pacific Basin under United States jurisdiction consists of the Trust Territory of the Pacific Islands made up of the Northern Marianas, and six districts (Palau, Yap, Truk, Ponape, Kosrae and Marshalls), miscellaneous islands and island groups under United States control (Guam, Johnston, Wake, Canton and American Samoa, etc.). The Trust Territory alone includes more than 2000 islands, 100 of which are inhabited.

In past years almost all stranding investigations have been on the major Hawaiian islands. These strandings include *Megaptera*, *Physeter*, *Ziphius*, *Mesoplodon*, *Steno*, *Kogia*, *Pseudorca*, *Globicephala*, *Peponocephala*, *Grampus* and *Stenella*.

History

Before the mid 60's there was little or no effort to recover stranded cetaceans in Hawaii. Between 1964 and 1972, Dr. K. Norris (then of the Oceanic Institute) responded to as many strandings as possible. Since 1970 either I or Sea Life Park employees have responded to every stranding of which we have been notified. Until the Marine Mammal Act of 1972, there was little interest by State or Federal authorities. Since that time, the National Marine Fisheries Service personnel have responded to most of the strandings.

There have been numerous problems in response to stranded animals. The most severe have been:

1. Lack of communication between people on outer islands and National Marine Fisheries Service.
2. Lack of funds and equipment.
3. Lack of coordination between State, County and Federal officials.

An attempt has been made to improve the situation by opening lines of communication with State and Federal officials through a series of meetings and workshops with NMFS, State of Hawaii Dept. of Fish & Game, U.S. Fish & Wildlife Service, U.S. Coast Guard and Sea Life Park. These have been partially successful but the lack of coordination has hindered recovery operations. Recoveries from other Pacific Islands have only occurred when an interested individual has made the effort to contact NMFS or Sea Life Park.

Proposal

It is possible to reduce or eliminate many of the problems which now exist by the implementation of a coordinated network. This network must

have the following characteristics.

1. It must be managed by a single individual or organization.

2. It should have a major educational emphasis that reaches the largest number of people possible and emphasizes the importance of marine mammals.

3. It should include individuals of all ranks, not just those of high authority.

4. It should incorporate continual communication and feedback.

5. Possible means of solving transportation and communication problems must be considered before strandings occur. Major logistical problems are often difficult to arrange on the spur of the moment, particularly in outlying areas of the Pacific.

6. The program must be funded.

I propose the following network:

Coordinator:	Government official with sufficient time and support, or small private organization coordinating the network on contractual basis.
Principal Contacts:	National Marine Fisheries Service State of Hawaii, Department of Fish & Game U.S. Fish & Wildlife Service U.S. Coast Guard Sea Life Park National Stranding Network

Secondary Contacts: (i.e., people on scene, logistical, etc.

State of Hawaii (Main Islands)

Scientific personnel interested in marine mammals

Local offices of Fish & Game, U.S. Fish & Wildlife Service, U.S. Fisheries Service

County Disposal Units

Sources of heavy equipment (i.e., trucks, cranes, bulldozers, etc.,

Community College personnel

Media (TV, Radio, Newspapers)

Transportation Companies

Other interested individuals

Trust Territory of the Pacific Islands

District Administrators

District Fisheries Officers

District Conservation Officers

Research Station Directors

Police

U.S. Coast Guard

NOAA Weather Stations

Newspaper Editors

Hotel Managers

Peace Corps

Transportation Sources

Traditional Chiefs

District Legislators and Legislative Bodies

Other Islands

U.S. Coast Guard Loran Stations

Interested individuals and other key people

Military Commanders

Transportation Sources

Media

NOAA Weather Stations

The coordination of this effort must begin with an educational program throughout United States-controlled areas of the Pacific. This has already begun in Hawaii, but not in the rest of the Pacific.

The method by which the system would work would best be described by a series of scenarios, using information based on previous strandings, as follows:

Scenario 1. On Thursday, I receive a radio message from Joyce Haas on Canton Island. She relates that for two days, four odd looking dolphins, 12-14 feet long, have been swimming in the lagoon and appear to be confused and disoriented.

From her description I surmize that they are of the genus Mesoplodon. I prepare to make the MAC flight going to Canton the next day. Before leaving, I notify the local office of NMFS, the Federal Stranding Alert Network Office and the local U.S. Custom's office. When I arrive in Canton, one whale is already dead and has been frozen. The whale is then shipped on the return flight and kept in cold storage until I return.

While I am on the island another whale strands. An autopsy is performed and specimens are taken. The carcass is frozen. With the aid of the islanders I am able to herd the remaining two whales to the opening in the reef through which they escape. On my return to Honolulu, reports of the stranding are filed and specimens are sent to those who had previously made requests.

Scenario 2. On November 17, I get word that about a week previously a calf of an unidentified mysticete whale has been stranded in a lagoon on a remote island in the Western Carolines. I contact the district fisheries officer who knows of a boat leaving for that area in two days. Ten days later I receive word from the fisheries officer that the whale was no longer on the island when it was checked.

Scenario 3. On 17 June 1976, seventeen rough toothed dolphins stranded on Maui. I was notified by the U.S. Coast Guard who have a SAR station near the stranding site. Immediately, NMFS was notified and we jointly responded. With the aid of the

U.S. Coast Guard, Pacific Sea Transportation and many local citizens, eight bodies were recovered. Five live animals were taken offshore and released, and one live animal was brought to Sea Life Park. The animal brought to Sea Life Park is still alive and doing well. Post mortems were later performed on all dead animals by the U.S. National Museum.

The cost of this proposal would probably be $50,000-75,000 for the first year and $35,000-50,000 annually thereafter. This is only a rough estimate and may vary considerably if a sufficiently large number of cetaceans are recovered.

PROPOSAL FOR A NORTHWEST NETWORK

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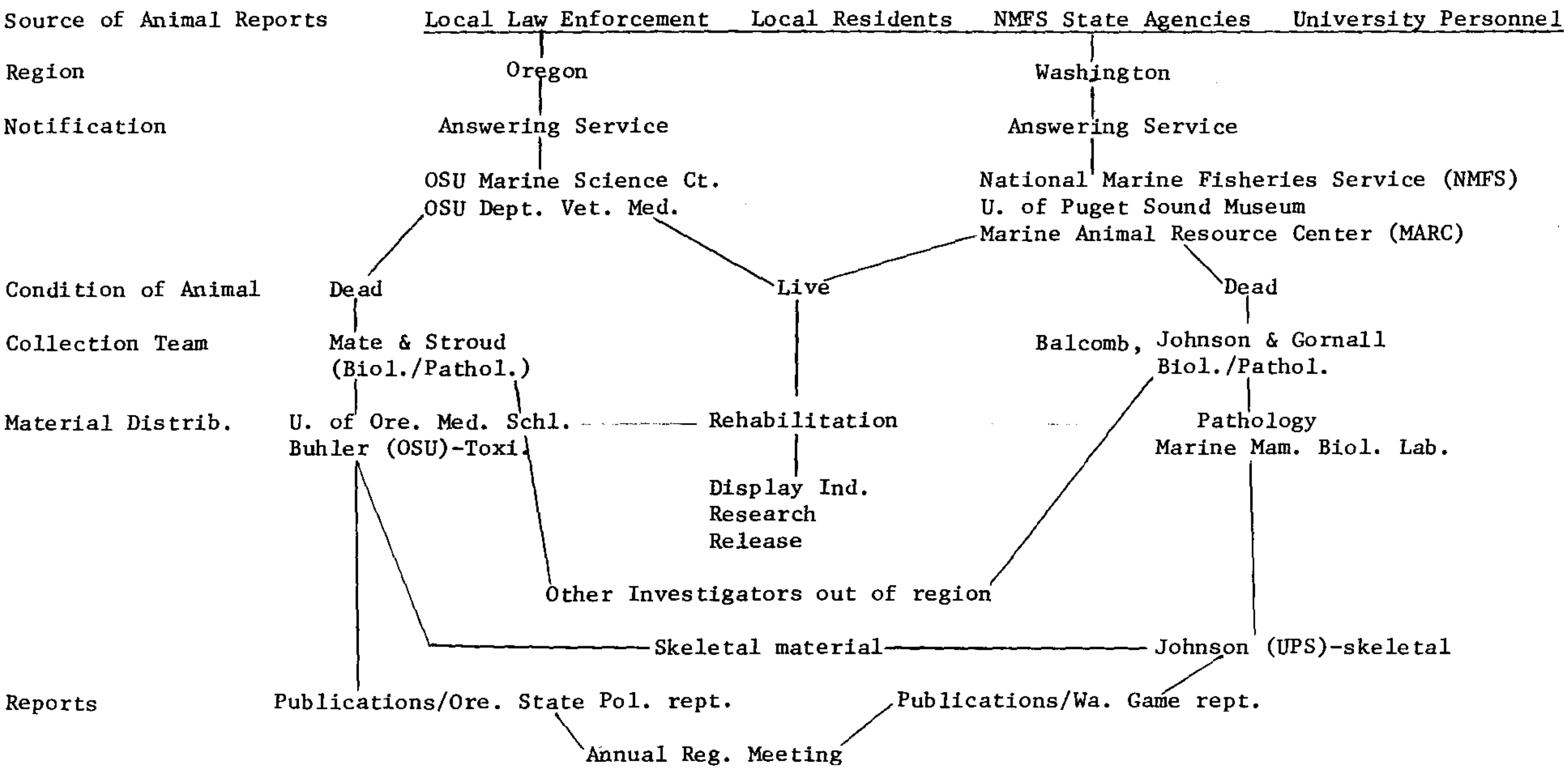
The four principal investigators who would be responsible for stranded animals in the northwest are Drs. Tag Gornall, Murray Johnson, Bruce Mate and Dick Stroud. The groups' relationships are shown on the accompanying flow diagram. Because of the large size of both Oregon and Washington coasts, each of these states will have its own notification procedure with good interstate communications for opportunities which require specialized skills. The Seattle Public Aquarium offers facilities and expertise to carry out a modest live animal rehabilitation program. Rehabilitated animals may be utilized within the display industry, or they could be returned to the wild. A number of field research situations exist in the northwest where these animals, if properly marked, could be observed to determine the success of their return. Such animals would supply information on regional and seasonal population movements.

Both states possess the personnel to do complete pathological and biological workup of stranded marine animals. There are facilities at Oregon State University which have the potential for in-depth disease research. These facilities would be available without development costs. Some support dollars are available, which could be used as matching funds. We feel it would be important for the principal investigators in regional programs to meet at least annually and that such meetings should include speciality training of participants as well as an information exchange.

NORTHWEST MARINE MAMMAL ALERT NETWORK



PROPOSAL FOR DEVELOPMENT OF A STRANDING ALERT NETWORK IN ALASKA

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Background

At least thirty species of marine mammals inhabit the waters adjacent to the 50,000 km coastline of Alaska, which is longer than that of all of the other coastal United States combined. While some of these species, such as the California gray whale and northern fur seal, are transient, most seem to be resident. A *pro rata* estimate of their numbers on a year-round basis is more than 2 million individuals. Some unknown proportion of these (perhaps 5 to 10 per cent) dies in Alaskan waters each year from various causes, and an unknown fraction of those that die (perhaps 1/50) strands on the Alaskan coast. Most of the Alaskan coast is remote. Therefore, access to most of the stranded marine mammals is difficult and expensive. Access is generally possible only after long flights on commercial arilines to the rural settlements, then via chartered boat or aircraft at inflated "bush" rates. For these reasons, an intensive state-wide stranding alert and recovery system has not been developed in the past.

Prior to the late 1950's, there were only a few records of strandings of marine mammals in Alaska. For example, Hanna (1920, 1923) recorded several walruses that washed ashore on the St. Matthew and Pribilof Islands, and Murie (1936), Collins (1940), and Cahalane (1947) described a mass mortality of walruses on the Punuk Islands in northern Bering Sea. Later,

Jellison (1953) briefly described a Mesoplodon beaked whale that stranded on the Pribilofs; Schiller (1954) reported a mass mortality of walruses at St. Lawrence Island; Geist et al. (1960) reported three records of stranded narwhals in the Bering and Chukchi Seas; and Kenyon (1961) reported two Cuvier's beaked whales that stranded on Amchitka Island in the Aleutian Chain. There were a few others, mainly in newspaper and magazine accounts, but the number reported per year was less than one.

An incomplete and very informal Alaskan stranding alert system was established by Fay in 1960 and continued through 1964, under the aegis of the Marine Mammal Committee of the American Society of Mammalogist. From 10 to 19 specimens per year were recorded at that time, and there were numerous indications of considerably greater numbers that became stranded and thus available for inspection. However, there was little interest in support of such a program at that time, and it became necessary to disband the system. In the meantime, further records were gathered on an opportunistic basis. This led to the planning and development in 1975 of a project on "Morbidity and Mortality of Marine Mammals - Bering Sea" (4-M)[1].

The 4-M project has included surveys of portions of the Bering Sea coast amounting to 1,450 km/yr for the past three years, in which were logged an average of 135/yr recently dead and moribund marine mammals and

[1]The 4-M study has been supported under contract 03-022-56 between the University of Alaska and NOAA, Department of Commerce, through the Outer Continental Shelf Environmental Assessment Program, to which funds were provided by the Bureau of Land Management, Department of the Interior.

about as many remains from previous years. The distribution of carcasses in uninhabited areas away from major pinniped hauling-out grounds is one per 25 to 30 km; strandings are about 10 times as frequent in the vicinity of major subsistence hunting sites and pinniped haul-outs. Carcasses were much more numerous (by at least two fold) on sandy and gravelly beaches than on rocky points and headlands, and their numbers were a function of weather and sea conditions, as well as surface currents. The carcasses persisted for only a short time in areas frequented by brown and polar bears, which carry away specimens up to the size of a large seal or small cetacean. All of the strandings were of species that are known to occur near shore within a few kilometers of the place where they were found.

Extrapolating from these findings, we predict that the number of marine mammals that strand on Alaskan beaches each year is at least 1,000. Our data suggest that most of these are dead on arrival, but this is difficult to evaluate from a once-per-year survey. The quantity of dead specimens from which valuable biological data can be obtained is prodigious and worthy of the effort and expense of examination.

For some species, it is feasible to obtain samples of adequate size to estimate natural mortality rates in relation to age and sex (e.g. walrus, gray whale, and perhaps sea otter). For these species and several others, information on causes of death also may be obtained, as well as basic data on reproduction, feeding habits, and growth.

Recommendations

The Alaska Department of Fish and Game (ADF&G) has compartmented the state into 26 Game Management Units, 18 of which include parts of the coast (Fig. 1). In each of these, there is at least one resident ADF&G game and/or commercial fisheries biologist who has good rapport with the local inhabitants and depends on them for current information concerning wildlife in the area. Since much of the information to be gained from stranded mammals, especially pinnipeds and sea otters, is likely to be of greatest value to the ADF&G research program, it is logical that these resident biologists should be the primary source of stranding reports gained from their own observations and those of the local inhabitants. It is probable that these people on the scene could obtain the minimal essential data and samples from many of the strandings, without seriously impinging on their other regular duties. When the numbers are too large or the specimens require special expertise in handling, the central coordination and response teams would be notified.

Central coordination and response teams could be developed in the three main population centers: Anchorage, Fairbanks, and Juneau. These teams might be made up of biologists from the University of Alaska branches in those three cities, as well as from the federal agencies and/or the ADF&G regional offices. Some funds need to be provided to each team for the investigators' time, transportation, and telephone services, but other costs could be carried in connection with general overhead of the agencies or institutions.

Of paramount importance in this system will be the development of a standardized, workable scheme for identification, necropsy, and reporting stranded animals. The possibility of a coordinated training program for

all participants should be considered.

The central coordination and response teams will be responsible for receiving and filing all stranding reports from the field biologists and lay volunteers in their region and, ultimately, for transmitting this information to the national data bank. They will also be responsible for notifying investigators in other states or countries whose special interests would be served by timely news of certain kinds of strandings. Of course, they would also keep the other Alaskan coordination centers apprised at all times of activities in their region. Finally, they would provide positive feedback to the field personnel and volunteers at frequent intervals, perhaps in the form of a newsletter.

Certainly, even this extensive program will not provide 100% coverage of the Alaskan coast on a year-round basis. Much of the coast, however, is icebound for several months each year and would not require coverage at that time. Experience may show that special effort would be cost effective at certain times in a few areas. In those cases, funding for a special project probably should be sought separately from a granting agency, rather than drawn from the stranding alert system budget. Funding for an Alaskan stranding alert system could be administered by the University of Alaska. It will not be feasible to apportion funds on a regional basis with certainty, since we cannot predict the level of activity in each region.

Budget

The following is an estimate of the minimal level of funding that would be needed in the first year of operation of the system.

SALARIES AND WAGES	
Coordination and Response Center personnel	$12,000
Field personnel	6,000
Staff Benefits (20% of $18,000)	3,600
TOTAL SALARIES, WAGES, & ST. BEN.	21,600
TRAVEL	10,000
EQUIPMENT	-0-
SUPPLIES	1,500
OTHER DIRECT COSTS	
Communication	1,500
Printing & copying	500
Shipping	500
Charter fees	3,000
Photographic	500
TOTAL DIRECT COSTS	39,100
OVERHEAD (50% of $18,000)	9,000
TOTAL PROJECT COSTS	$48,100

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3. GEIST, O.W., J.L. BUCKLEY and R.H. MANVILLE. 1960. Alaskan records of the narwhal. J. Mammal., <u>41</u>: 250-253.

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6. JELLISON, W.L. 1953. A beaked whale, <u>Mesoplodon</u> sp., from the Pribilofs. J. Mammal. <u>34</u>: 249-251.

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8. MURIE, O.J. 1936. Notes on the mammals of St. Lawrence Island, Alaska. <u>In</u> O.J. Geist and F.G. Rainey. <u>Archaeological Excavations at Kukulik, St. Lawrence Island, Alaska</u>, pp. 337-346. Misc. Publ. Univ. Alaska, Fairbanks.

9. SCHILLER, E.L. 1954. Unusual walrus mortality on St. Lawrence Island, Alaska. J. Mammal., <u>35</u>: 203-210.

APPENDICES

STRANDING WORKSHOP ATTENDEES

List of registered attendees at the Marine Mammal Stranding Workshop held in Athens, Georgia, on August 10 through 12, 1977. Program participants (*) and members of _ad hoc_ committee (+) proposed in the report are designated.

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MARINE MAMMAL STRANDING WORKSHOP PROGRAM

10 August 1977

SESSION 1	A REVIEW OF THE STRANDING PHENOMENON
1300-1310	Opening Remarks and Introduction of the Program - J. Geraci
Part A	The Nature and Occurrence of Marine Mammal Strandings - E. Mitchell, Chairman
1310-1335	An analysis of cetacean strandings along the east coast. J. Mead
1340-1405	An analysis of cetacean strandings along the west coast, to 1965. E. Mitchell
1410-1435	An analysis of strandings along the British Isles. M. Sheldrick
1440-1505	Pinniped and sirenian beachings. L. Garibaldi, J. Sweeney, D. Odell & E. Asper
1510-1525	Break
Part B	Stranding Theories - F. Wood, Chairman
1525-1610	Stranding theories; their strengths and weaknesses. F. Wood
1620-1640	Do parasites contribute to strandings? S. Ridgway, W. Walker, M. Dailey, W. Perrin & J. Geraci
1645-1705	Population size and stranding: cause or effect? D. Sergeant
1710-1725	Lemming behavior; a possible parallel to strandings? R. Brooks
1730-1930	DINNER

10 August 1977

1930-2200 Concurrent Study Groups For Parts A & B

<u>Part A Study Group</u>

- <u>Stranding analysis and data collection</u>

E. Asper; T. Dole; L. Garibaldi; B. Mate; J. Mead; E. Mitchell, Chairman; D. Odell; S. Leatherwood; D. Schmidley; M. Sheldrick; W. Walker.

This study group will address questions, and <u>provide specific recommendations</u> as follows:

- How can stranding data be maximized?
- Where are the gaps in the present data?
- What data are needed to better understand the nature and occurrence of strandings?
- How can uniformity in data collection be assured?

<u>Part B Study Group</u> - <u>Stranding theories</u>

D. Caldwell; M. Caldwell; W. Dudok van Heel; J. Geraci; W. Perrin; S. Ridgway; W. Schevill; D. Sergeant; F. Wood, Chairman.

This study group will:

- Identify all present stranding theories.
- Identify the strengths and weaknesses of each theory.
- Identify those weaknesses which are due to a lack of data.
- Recommend steps which must be taken in order to bridge the gaps in data.

11 August 1977

SESSION 2 INFORMATION GAINED FROM STUDIES ON STRANDED ANIMALS
D. Forrester, Chairman

0900-0920 Regulations and guidelines relative to handling stranded animals.
R. Brumsted

0925-0940 Onsite problems and solutions.
C. Skinder and J. Mead

0945-1000 Break

Part C Biology and Life History
(Session 2 Parts A and B are concurrent with Session 3)

1000-1015 A mass stranding of *L. acutus* as an opportunity to study life history.
S. Testaverde

1020-1035 Film documentation of a stranding of *P. crassidens* in Florida.

1040-1055 A summary of information derived from a mass stranding of *P. crassidens* in Florida, 1976.
D. Odell and E. Asper

Part D Parasites and Diseases

1100-1120 Strandings as an opportunity to study stress and diseases in wild populations.
J. Geraci and D. St. Aubin

1125-1140 Neuropathology in relation to stranding.
N. Hall et al.

1145-1200 Parasites as an aid to understanding marine mammal populations.
M. Dailey

11 August 1977

SESSION 3	LIVE ANIMAL SALVAGE PROGRAM (this session is concurrent with Session 2 Parts C & D) S. Ridgway, Chairman
1000-1015	Retrieval of strandlings. S. Ridgway
1020-1035	Nursing care of strandlings. E. Asper, C. Skinder, T. Otten and L. Smalley
1040-1055	Medical care of strandlings. J. Sweeney and J. Geraci
1100-1115	Rehabilitation of sea otters. J. Antrim
1120-1135	The quandry of whether to retain or release rehabilitated strandlings. S. Ridgway and J. Prescott
1140-1200	Open Discussion
1200-1400	LUNCH
1400-1700	Concurrent Study Groups, Sessions 2 and 3.

Session 2 Study Group - Information Gained from Studies on Stranded Animals.

D. Cowan; D. Forrester; J. Geraci, Chairman; C. Jones; T. McIntyre; D. Odell; W. Perrin; J. Popp; J. Prescott; H. Winn and J. Woodard.

This group will address the following questions:

- What information has been gathered on the biology of marine mammals (i.e. population structure, life history, reproduction etc.) through stranding investigations?
- What information has been gathered on diseases of marine mammals?
- What role does disease play in wild populations?
- What information has been gathered on man-animal interactions (i.e. harassment, habitat destruction, environmental pollutants, etc.)?
- What is the relevance of such data in terms of marine mammal management policies?
- Which federal and state agencies require such information in order to determine management policies?
- What procedures should be followed during a stranding investigation so as to maximize the data on biology, parasites, disease, oceanic monitoring, etc.?

11 August 1977

Session 3 Study Group Care of Strandlings

J. Antrim; E. Asper; W. Lewis; T. Otten; S. Ridgway, Chairman; C. Skinder; L. Smalley; R. Whittaker.

The group will consider all aspects of the handling of live beached animals, and formulate guidelines and recommendations on:

- onsite procedures for immediate care
- efforts to return stranded animals to the sea
- capture and handling of strandlings
- nursing care
- medical care
- rehabilitation of animals for exhibition

12 August 1977

SESSION 4	REGIONAL STRANDING ALERT NETWORK J. Prescott, Chairman
0900-0910	A developing network in New England J. Prescott
0915-0925	Proposal for a northeast network J. Prescott, R. Whittaker, H. Winn, J. Mead & W. Medway
0930-0940	Proposal for a southeast network (Principal to be announced), C. Fuss, J. Mead, D. Schmidly, and D. Forrester
0945-0955	Proposal for a northwest network. B. Mate, W. Lewis and T. Gornall
1000-1015	Break
1015-1025	Proposal for a southwest network W. Evans, G. Smith, W. Walker and W. Perrin
1030-1040	Proposal for a Hawaii network E. Shallenberger
1045-1055	Proposal for an Alaska network F. Fay and R. Naab

12 August 1977

1100-1230 Session 4 Study Group - Regional Network

Session 4 Study Group <u>Regional Networks</u>

Panelists include all representatives of Regional Networks
J. Prescott, Chairman.

The group will formulate guidelines based on the following questions:

- How can networks be established which are consistent from region to region?
- How should the notification process be handled?
- What agencies, federal, state, local and institutions are involved in each region?
- How should response teams be structured?
- What are the priorities in handling live animals?
- What are the priorities in the dead animal salvage program?
- What agency is ultimately responsible for the disposition of stranded animals?
- How should funds be allocated on a regional and national basis?

1230-1245 Break

SESSION 5 PANEL DISCUSSION ON A NATIONAL DATA CENTER
Chairman, (C. Jones)

1245-1445 working luncheon

This open panel will discuss the needs, organization and location, and financing of a central data bank, and mechanisms for data input and retrieval. Panelists will include:

R. Brownell
R. Brumsted
C. Jones
T. McIntyre
J. Prescott
U. Seal

in addition to all of the representatives from regional networks.

1445-1500 Concluding Remarks
J. Geraci